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U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 116.
B. T. GALLOWAY, *Chief of Bureau.*

THE TUNA AS FOOD FOR MAN.

BY

DAVID GRIFFITHS,

ASSISTANT AGROSTOLOGIST, FARM MANAGEMENT INVESTIGATIONS, BUREAU OF PLANT INDUSTRY.

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ISSUED DECEMBER 2, 1907.

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[Continued on page 3 of cover.]

D. G. Passmore

TUNA CARDONA.

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U. S. DEPARTMENT OF AGRICULTURE.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., July 23, 1907.

Sir: I have the honor to transmit herewith a manuscript entitled "The Tuna as Food for Man" and to recommend that it be published as Bulletin No. 116 of the series of this Bureau. This bulletin was prepared by Dr. David Griffiths, Assistant Agrostologist in Farm Management Investigations, Bureau of Plant Industry, and Prof. R. F. Hare, Chemist of the New Mexico College of Agriculture and Mechanic Arts.

This bulletin represents three lines of investigation—a study of the uses of the tuna (pronounced *too-nah*), a study of the chemical composition of the tuna, and a study of the tuna products as manufactured by the primitive peoples of the Republic of Mexico. The authors have joined these three lines of work in one report.

There is presented in the paper actual economic practices which are of interest not only to portions of the United States but to some of its insular possessions as well, botanical data necessary to the recognition of different species and varieties, and a large amount of chemical information of unusual interest. The botanical notes have been abridged as much as is consistent with a clear presentation. In many cases they have been omitted almost entirely; in all such cases, however, they will be found more fully presented in Bulletin No. 60 of the Agricultural Experiment Station of New Mexico.

Interest in cacti in general, from both a food and a forage standpoint, has been greatly stimulated by popular writers during the past two or three years, and such investigations as are here recorded are therefore of special value at this time. In order to secure a basis for future investigations in the development of forms better adapted to our use, it has been necessary to treat the subject from the broad point of view of the entire continent rather than of the United States only. A few valuable tunas are now grown within our borders, while the Mexican species are very numerous. Many of the latter have very desirable characteristics which if combined

with species now grown here would make a very superior fruit. The data presented in this bulletin, while intended mainly as an account of the tuna as it exists to-day in the United States and Mexico, furnish a foundation for future investigations in the development of more desirable forms, a work which is now in progress.

Tuna is the Spanish name for the fruit of the prickly pear plant—that section of the botanical genus Opuntia which bears flat-jointed stems. A discussion of the fruit of one Opuntia with cylindrical joints is also included in the bulletin for reasons stated in the text. Many other cactus fruits should be investigated. Some work has already been done upon them and will be continued as time permits. The term pitalla (pronounced *pee-tah-ya*) is used by the Mexicans for a very large and heterogeneous group of cactus fruits belonging to such botanical genera as Cereus, Echinocereus, Echinocactus, Pilocereus, etc.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE TUNA AS FOOD FOR MAN.

INTRODUCTION.

The prickly pear of the American and the Australian, the Indian fig of the Englishman, the Barbary fig of the Frenchman, the tuna of the Spanish-American, and the higos chumbos of the Spaniard is a fruit concerning which there are more varied beliefs, contradictory opinions, and grades of appreciation than any other known to us. The plant and its fruit are subjected to both praise and abuse.

While the Mexican prays that there may be no rain when the plants are in bloom, in order that the fruit may set well and produce a good crop of tunas, the legislative assemblies in some of the Australian colonies pass laws looking toward their eradication. While the Australian governments spend much money to eradicate the "weed," some ranchmen find that it can be fed to stock with profit. While the southern Texan was imploring the Government in the early nineties to conduct investigations looking to the eradication of prickly pear, shrewd cattlemen and ingenious machinists were devising means whereby it could be divested of its objectionable characteristics at small expense and turned to profitable use. While the minister of agriculture of India pronounced against its use in unqualified terms, it was found that it could be profitably used in both beef production and dairying in at least one section of the United States. While the South African is said to revile its presence, the poorest inhabitants of the Island of Sicily are reported to subsist largely on its fruit for three or four months of each year. The average American traveling in Mexico can see no value whatever in the tremendous stretches of prickly pear upon the plateau, but the native peon grows these and similar cacti in his orchards and gives them fully as careful attention as any plants which he attempts to cultivate.

Enthusiastic magazine writers would revolutionize conditions in arid regions by the establishment of plantations of prickly pear without spines, thus converting the most arid deserts into populous, prosperous communities. Experience teaches, however, that the spineless varieties of cultivation are not hardy under natural desert conditions, that all of the valuable spineless species which produce either fruit or forage in economic quantities require considerable

precipitation at some time during the year, and that economic species are not known which thrive under a minimum temperature of less than 10° F. One exception to this may be noted in the case of *Opuntia arborescens* of Colorado; but the quantity of stock feed produced by this species is comparatively small and its distribution limited.

Conservative judgment based upon observation and experiment, on the other hand, would pronounce many species of prickly pear to be decidedly susceptible to cultivation and highly productive of both fruit and forage under proper conditions of temperature and moisture. It is also true that there are species which thrive under moderate extremes of heat; that, as a rule, they are adapted to conditions of periodical rainfall and thrive where the distribution of moisture is too irregular and uncertain for commonly cultivated crops; that the spines and spicules have been practically eliminated from the plant body in valuable species but not from the fruit; that all of the so-called spineless forms concerning which there is definite knowledge are less hardy, especially under conditions of drought, than spiny native forms; that it is quite probable that by persistent breeding and selection the spines and spicules may be more completely removed and the plants bred to withstand a greater degree of cold; that the plants can be fed with concentrated foods with profit; that the fruit is now, in its spiny condition, an important and highly prized constituent of the diet of the poorer classes, especially of Mexico and Sicily; that very desirable food products are prepared from the fruits, and that the group is of sufficient economic promise to merit thorough investigation.

THE COMMON NAMES OF TUNAS.

The common names which are used in this bulletin have been selected with the utmost care. They are based upon a careful investigation of all of the important prickly pear regions of the United States and Mexico. Unless otherwise indicated, it is believed that they are accurate. In each instance, unless the name is questioned in the text, it has been verified many times. The orthography of the common names has, in nearly every case, been verified by educated Mexican gentlemen and accords with the ideas of the writers concerning derivation. Señor Enrique L. Guerra has corrected the list of popular names and has made important suggestions and contributed much valuable information upon all phases of the subject.

The popular names are as a rule quite the same in any one locality, but there may be great variation between the names of species in different localities. Some well-marked species, however, have appar-

ently the same name wherever found. The use of the names cardon, tapon, camueso, and amarillo is, so far as the experience of the writers goes, universal; but these are very characteristic species which even the least observant can not well mistake. It is entirely different with the yellow or green fruited forms (including the tame or cultivated ones). These have a multitude of names. Some of them may and probably do represent good specific distinctions. On this point it is impossible to speak with certainty, for the writers' experience with the different forms has not been sufficiently extensive. Some of the plants are spiny, others almost perfectly spineless, and even in some cases apparently without spicules on either fruit or joint. In general aspect they are all very much alike, and the names applied to the different forms do not appear to be at all uniform. Some of the names used for the greenish-white-fruited forms, for example, are as follows: Nopal blanco, nopal teco, nopal paloalteno, nopal fafayuco, nopal Mexicano, nopal Americano, and nopal Castillo blanco, while nopal liso is commonly used, though the latter name is applied to any thornless form. They all appear to be closely related to one form of our southwestern "mission pear," although in this country this is nearly always a thorny form, while the greenish-yellow-fruited forms of Mexico may exhibit any degree of spininess.

It must be understood that any list of common names of Mexican tunas can be of only tentative value, for there may be even less uniformity in popular names in Mexico than in this country. In any one locality, however, the name used for a species or variety is reasonably constant. The commercial spirit has had no influence in changing names.

As with many other natural and agricultural subjects, it is the native peon who is the court of final resort to decide upon the names of plants. The rancher when asked regarding such matters will almost invariably put the question to one of his more intelligent servants. The names used in this bulletin have been obtained mainly from the peons and have subsequently been verified and corroborated by educated and intelligent ranchers.

THE CULTIVATION OF THE NOPAL.

There are in Mexico many varieties of prickly pear which are found only in cultivation. This is especially true of the spineless forms in general. Others are native and may or may not be cultivated. Of the first group the peon may speak collectively as mansas, or tame forms, but he has names for all of the varieties which are grown in his orchards as well as for the wild ones of the mountains. To say that any of the forms are cultivated as we think of cultivation in

this country, however, is a gross error. They are rarely cultivated at all. Cuttings are put into the ground and surrounded by a fence to protect them from animal depredations. Aside from this they get little or no attention.

A plantation is always started from cuttings; consequently it is an easy matter to maintain uniformity in the plants. Inasmuch as it is always an object to get tunas as soon as possible, the stock-feed feature of the crop being always a secondary consideration, cuttings of three joints are planted when possible. (See Pl. V, fig. 2.) A cutting consisting of two and a half joints is common. When planted in this way it is said that a crop of tunas is produced the third year, while it takes five years to get a crop from one-joint cuttings.

Plantations are not confined to the mansas. On the contrary, the wild forms will often be found in the orchards under protection and are even planted without protection in the hills. Such forms as the cardon are admirably adapted for this purpose, for no animal can molest them much. The thickets of this species east of San Luis Potosi have been greatly extended by planting cuttings in unoccupied areas. Several acres were planted there last year. How much of this has been done in the past it is difficult to say, for it is not always easy to tell the difference between areas which have been planted and those which are wild. Quite likely many of the thickets found in the hills have been, in a measure, established through the influence of man, some of them unwittingly, for the method of collecting the fruit scatters joints about, many of which strike root and grow. Some of the thickets in the vicinity of Alonzo, Mexico, are being slowly extended by this method of collecting the fruit.

THE TUNA MARKETS.

A very distinctive feature of the markets of the different cities of the highland region of Mexico is the space or booths assigned to the sale of tunas. The business is generally carried on by the poorer people in the most simple and primitive way. Not that the poor are the only ones who eat tunas, but they are eaten more extensively by the poorer class than by any other.

During the greater part of the season purchasers come to these booths—distinguished by the size of the individual awnings or by the length and number of the benches and stools—where they may purchase one or more varieties of fresh tunas at a very low price. The purchaser is supplied with a stool, upon which he can sit, and a knife with which to peel the tunas. During the height of the season when the fruit is cheapest, women appear on the markets each morning with huge baskets of peeled fruits, which they lay out in earthen

saucers, each containing a quantity which is disposed of for 1 cent. Each purchaser is furnished with a tip of a maguey leaf or a thorn of the mesquite with which to eat the pulp, and in a few instances modern wooden toothpicks are served with them.

By far the greater quantity of fruit is sold unpeeled. This is especially true during the season when fruits are not abundant, for less waste results then than when the tunas are peeled. Sometimes the purchaser peels the fruit himself and at other times he eats it as the vendor or his attendant peels it for him.

The process of peeling on the market is practically the same as described later, the knife being run across the top and down one side to the base, when the pulp may be picked out easily. When fully ripe much of the rind of some species is consumed with the pulp. The tuna is taken between the thumb and forefinger of the left hand and the rind cut off with a sort of whittling motion of the knife, each stroke taking off the epidermis and a portion of the rind, but not more than one-half of the rind is ever eaten. In peeling the larger mansas (cultivated forms), both ends are usually cut off and an incision made through the rind lengthwise between these two cut surfaces, when the remainder of the outside is removed by pushing it back with thumb and forefinger of each hand.

To remove the spicules so that the fruit can be more easily handled the vendors employ several simple devices. Sometimes the tunas are rolled around upon the sand with the aid of a bundle of small twigs or a bunch of weeds. At other times they are actually brushed with a wisp of grass or a brush made of maguey fibers. Often they are stirred in a pail of water. Any of these processes will remove the spicules fairly well if the fruit is thoroughly ripe. It should be remembered that there are no prickly pears without spicules. Even the so-called thornless ones which have been developed in the Mediterranean region, and eight or ten of which have been apparently produced in Mexico, have some spicules upon the fruit, although the spines have been quite effectually bred off the body of the plant. Also, in nearly all cases there are produced upon the fruits hairlike, fugacious spines, most of which drop off or are easily removed when the fruit is ripe. The spicules are the most serious obstacle to the use of this fruit.

As previously stated, it is the pulp which is usually eaten; less often some rind is also consumed with it. It is well known that the pulp itself is very seedy, and on this account the fruit is very objectionable to the average American; the Mexican, however, swallows seeds and all with apparent indifference. The species of which both the pulp and rind are eaten are mainly cardonas late in the season, and durasnillas. In the latter fruit the pulp is not easily separated from the rind, but in the former the rind is removed without difficulty.

The price of tunas upon the market varies greatly with the season. During the past year the cheapest were found at San Luis Potosi, where 15 to 20 cardonas were sold for a cent [a] and the large mansas as low as six for a cent. In Guadalajara, where tunas are rare, three to five cardonas were commonly sold for a cent and one amarilla, naranchada, or other mansa for the same price. During the month of August cardonas were selling wholesale at San Luis Potosi for about 45 to 50 cents a crate of a thousand tunas; at the same time they were sold upon the market at the rate of 14 for a cent. It is said that one man can pick about three crates a day.

An attempt was made to determine how much of this fruit is eaten by the average peon in a day, but with no satisfactory results. The writers have repeatedly seen men eat from 25 to 50 tunas without stopping, and peons affirm that they eat an average of about 100 a day. It is believed, however, that where the diet is made up largely of tunas, and they are conveniently at hand, upward of 200 a day are consumed by one individual. Intelligent and conservative ranchmen estimate that a man will easily consume many more than 200 cardona pears per day when in the hills where practically no other food is available. This fruit represents very often in the largest measure both food and drink, but it seems like a very heavy ration when one considers that the seeds as well as the pulp are swallowed. It has been the experience of the writers that one not accustomed to the fruit can eat 60 to 80 tuna cardonas a day if the seed is not swallowed, and they have eaten as many as this occasionally in about two hours' time.

It must be remembered that the pulp of 40 to 50 tunas (cardonas) forms quite a bulky meal; the seeds are, of course, not digested. It is claimed that only a few of the species can be eaten in large quantities without danger. There is said to be no danger from eating any number of cardonas unless it be immediately after a heavy meal consisting largely of meat. On the contrary, it is claimed that the mansas must be partaken of sparingly on account of their interference with digestion when eaten too freely. Peons are very careful in eating taponas because they believe that these fruits produce intense constipation. They claim that death has resulted in some cases from eating too much of this fruit.

The excreta, both solid and liquid, are decidedly colored when the red tunas, especially taponas, are eaten. So far as the writers have been able to learn, however, the tuna cardona is the universal favorite and apparently its use as food results in no injury whatever, even

[a] Unless distinctly specified to the contrary, the prices quoted are in Mexican currency. Equivalents for the United States can be determined approximately by dividing by two. A Mexican dollar equals 50 cents of the currency of this country, while a cent in Mexican money is worth only half a cent in the money of the United States.

when partaken of very freely. The explanation offered by the natives as to the injurious effects of the mansas is that they are too rich.

Where there are so many tunas consumed there is, of course, a large quantity of rind available for stock food, while in the manufacture of queso and other products the quantity of seed taken out is quite large. Upon one ranch visited the by-products were fed to hogs. Upon the markets at San Luis Potosi during the month of August the rinds were selling at the rate of 10 to 12 cents a basket of about 50 pounds and were consumed largely by dairy cattle. They were also fed to burros and swine.

GENERAL DESCRIPTION OF THE FRUITS.

The fruits of the prickly pear vary in size, shape, and color, depending upon the species and the conditions under which they are grown. They are from 1 to 3 inches in diameter and are usually pear-shaped or fig-shaped, but in some species they are nearly spherical. They weigh from an ounce to a half-pound or more and vary when ripe from a yellowish green to a dark purple.

All varieties have minute spicules arranged in bunches over their surface, there being about one bunch to every square inch of surface in the best varieties, but in most species they are more numerous than this. The fruits of nearly all of the species have large spines also, which are similar to those on the plant body, but are much more delicate and usually drop off before the fruits are thoroughly ripe. A cross section of the fruit shows it to be covered with a thin skin, or epidermis, underneath which there is a rind varying in thickness from one-eighth to one-half of an inch. This includes the pulp, or edible portion, in which there are found embedded from 100 to 200 or more seeds. In some fruits as many as 400 have been counted.

THE EPIDERMIS.

The epidermis is the thin outer skin, and, whether the fruits are eaten raw or in conserved products, it is necessary that this be removed because of the tiny spines occurring in bunches over its tough, leathery surface. When the fruits are peeled, a part of the rind is removed along with the epidermis.

THE RIND.

The fruit itself is found enveloped in what is morphologically a portion of the stem, but which we have called rind. It partakes of the nature of both fruit and stem, usually assuming the color of the fruit and somewhat approaching it in composition. In some varieties it contains sufficient sugar to make it edible, but it usually retains so much plant mucilage, always present in the stems, that it

is not as palatable as it would otherwise be. Except in the formation of some sugar as the rind ripens and the change in coloring matter, the rind retains the general cell structure and appearance of the stems.

The rind is usually easily separated from the pulp. It constitutes from 25 to 75 per cent of the fruit, and when this is not eaten there is, of course, a very large percentage of waste. Consequently, the fruit which has the thinnest rind is the most desirable.

In a number of species where the waste was large and the rind was at all palatable, a separate analysis was made of the rind to determine its nutritive value compared with the pulp. The results are given in Table I. By comparing the results given in this table with the analyses of the pulp in Table II it will be seen that the percentage of both the total and soluble solids of the pulp is greater than that of the rind. In fact, about 50 per cent of the solids of the rind are in an insoluble form, whereas in the pulp the solids are almost completely soluble. In the rind the acid is always comparatively high, as is also the alcohol precipitate, both of which make the fruits unpalatable. The specific gravity of the juice of the rind is always less than that of the pulp, and the sugar content is also much smaller. The results of our analyses show that the rind at times contains some sucrose, which seems more often to be lacking in the pulp.

TABLE I.—*Analyses of the rind of tunas.*

Collector's number.	Scientific name.	Common name.	Number of fruits per pound.	Weight.	Waste (peeling).	Composition.																
						Total solids.	Soluble solids.	Specific gravity of juice.	Total solids in juice.	Total proteids.	Albuminoids (N×6.25).	Amids (N×4.25).	Water-soluble proteids (N×4.25).	Acids expressed as H_2SO_4.	Polarizations.		Temperature.	Sucrose by polarization.	Sucrose by reduction.	Total sugars as dextrose (Allihn).	Ash in soluble solids.	Alkalinity of ash as K_2CO_3.	Alcohol precipitate (mucilage, salts of organic acids, etc.).
															Direct.	Invert.							
				Grams.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*		° *C.*	*P. ct.*	*P. ct.*	*P. ct*	*P. ct.*	*P. ct.*	*P. ct.*
8065a	Opuntia robusta	Tuna tapona	2.20	210.60	.....	.....	.....	1.041	9.85	.....	.....	.....	.....	0.130	+1.3	+1.30	34	0.00	.....	.....	.....	.....	.....
8057	Opuntia sp	Tuna amarilla	4.80	94.00	30.85	.....	.....	1.038	9.15	.....	.....	.....	.....	0.231	+0.20	+0.20	28	0.00	0.57	4.09	.....	.....	.....
8051	Opuntia streptacantha.	Tuna cardona	10.34	43.83	38.01	.....	.....	1.030	7.27	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.62	4.49	.....	.....	.....
8099	.....do	.....do	9.06	50.00	29.42	14.96	12.81	1.040	9.62	0.193	0.104	0.088	0.149	0.211	.....	.....	.....	.....	.....	.....	1.38	0.249	.....
[1] 8099	.....do	.....do	.....	.....	.....	10.40	10.03	1.040	9.62	0.166	0.122	0.044	0.141	0.211	+2.3	+0.90	30	1.05	1.58	6.63	1.10	0.223	.....
[2] 8099	.....do	.....do	9.24	49.00	38.29	.....	.....	.....	.....	.....	.....	.....	.....	.....	+2.2	+1.20	30	0.75	.....	7.74	.....	.....	.....
[3] 8099	.....do	.....do	9.64	47.00	49.73	13.35	11.37	1.040	9.62	0.244	0.104	0.140	0.179	0.215	+2.8	+0.80	29	1.50	1.32	7.74	0.250	0.207	1.800
8109	Opuntia sp	Tuna chaveña	6.80	66.50	58.48	.....	.....	1.032	7.74	.....	.....	.....	.....	0.955	+0.4	+0.40	28	0.00	0.79	4.97	.....	.....	.....
8119	.....do	Tuna agua-miellilla.	14.70	30.84	46.72	.....	.....	1.030	7.27	.....	.....	.....	.....	0.497	+1.3	+0.80	29	0.38	0.00	2.76	.....	.....	.....
8135	.....do	Tuna joconoxtle	11.00	41.17	55.76	6.71	4.37	1.025	6.09	2.830	0.104	0.179	0.223	0.443	+1.3	+0.40	27	0.69	0.00	3.31	1.19	0.808	0.233
8143	Opuntia leucotricha.	Tuna durasnilla blanca.	10.60	42.90	58.40	10.22	6.92	.....	.....	0.190	0.130	0.060	0.074	0.910	+0.4	−0.50	24	0.68	1.05	6.08	0.79	0.700	.....
8150	.....do	Tuna durasnilla colorada.	11.10	40.60	58.86	8.95	7.17	1.036	8.68	0.228	0.109	0.119	0.100	0.435	+1.6	+0.40	25	0.89	2.06	6.63	0.89	0.570	0.760
	Average		9.04	65.13	46.14	10.77	8.78	1.035	8.49	0.217	0.112	0.105	0.144	0.424	+1.4	+0.59	28.4	0.59	1.89	5.44	0.93	0.460	1.630

[1] Juice only.

[2] Ten days after gathering.

[3] Twenty days after gathering.

THE PULP.

The pulp is the portion of the fruit that is eaten in all varieties. In some species it is insipid, but in many it has an excellent flavor. We believe that Americans will acquire a liking for this fruit more readily than they do for tropical and subtropical fruits in general. The amount of pulp in the different varieties varies from 30 to 65 per cent, and as a rule those with a large percentage of pulp have the best flavor.

The structure of the pulp is rather peculiar for a fruit. The walls of the cells are very thin, and there is consequently very little fibrous substance in its make-up, and, indeed, but little insoluble solids in the majority of the species. By pressing the pulp in muslin bags practically the entire quantity can be forced through the meshes of the cloth. This was found to be the most satisfactory method of separating the seed from the pulp, and was adopted in our analytical work. The small amount of fibrous tissue is shown by the quantity of insoluble solids, which averages less than 1 per cent for all the samples.

There is great variation in the composition of the pulp of different species and even of the same species at different seasons or degrees of ripeness. The amount and character of the edible matter vary a great deal in the different samples, as will be seen when the various constituents of the edible portion are discussed. Several varieties have been worked in duplicate, and by referring to the tables it will be seen that frequently the two analyses are very different. This may be accounted for in several ways. In the first place, the fruit may be eaten at varying degrees of ripeness. The pulp of the tuna tapona, for instance, is palatable at least two weeks before the outside of the fruit turns red and is commonly eaten from the time the pulp turns red until the outside is a deep purplish color. The time which it takes for these changes to occur in the fruit is not less than a month. Browne[a] has found that apples, and Bigelow[b] that peaches, vary a great deal in composition at their different periods of growth, and in all probability the same would be found true of fruits of the cacti. The season, climatic conditions, and soil fertility no doubt affect the composition of this fruit as they do all others.

THE SEED.

The seeds (see Pl. VI) are distributed throughout the mass of the pulp. They are somewhat disk shaped, and are from one-eighth to three-sixteenths of an inch in diameter. The seed coats are very hard and are never masticated or digested when the fruit is eaten. Each fruit contains a large number of seeds, varying somewhat with the different varieties. Some of the samples analyzed had no more

[a] Pa. Dept. Agr., Bul. 58.

[b] U. S. Dept. Agr., Bureau of Chemistry, Bul. 97.

Composition of edible portion.

Water-soluble proteids (N×4.25).	Acids expressed as H_2SO_4.	Polarizations.		Temperature.	Sucrose by polarization.	Sucrose by reduction.	Total sugars as dextrose (Allihn).	Ash in soluble solids.	Alkalinity of ash as K_2CO_3.	Alcohol precipitate.
		Direct.	Invert.							
Per ct.	*Per ct.*			° *C.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
0.156	0.700	+0.300	−0.400	30	0.53	0.00	7.18	0.17	0.027	.....
.....	1.180	.....	.....	.....	.....	.....	0.85	.....	.....	.....
0.284	0.880	−0.500	−0.700	26	0.15	0.41	5.24	0.42	0.276	0.394
.....	.....	±0.00	±0.00	24	0.00	0.00	1.41	.....	.....	.....
.....	2.150	.....	.....	.....	.....	.....	0.00	.....	.....	.....
0.220	1.228	−0.067	−0.367	27	0.23	0.14	2.94	0.30	0.152	0.394
0.252	.....	+2.00	.....	.....	.....	0.35	9.76	0.37	0.033	.....
0.268	0.038	+1.10	+0.700	29	0.30	0.00	11.05	0.24	0.062	0.200
.....	.....	+2.40	+2.400	30	0.00	0.00	8.84	.....	.....	.....
0.149	0.076	+2.30	+2.000	29	0.15	0.00	9.95	.....	.....	0.200
.....	0.040	+1.50	+1.100	28	0.31	0.58	11.05	0.23	0.140	0.394
.....	.....	+1.20	+0.300	20	0.68	1.04	9.07	.....	.....	.....
.....	.....	.....	.....	.....	.....	0.69	10.44	.....	.....	.....
0.164	0.320	+1.00	+1.000	25	0.00	0.00	8.84	0.30	0.460	0.180
0.100	0.079	+0.30	+0.300	25	0.00	0.00	8.84	0.27	0.170	0.210
.....	.....	+0.80	−0.100	24	0.68	0.26	7.08	.....	.....	.....
0.387	0.078	+1.80	+1.60	26	0.15	1.58	8.29	0.20	0.120	0.250
.....	.....	+1.00	+0.50	24	0.38	0.32	8.99	.....	.....	.....
0.342	0.062	+0.90	+0.80	26	0.08	0.00	9.12	0.20	0.180	0.280
.....	.....	−0.20	−0.50	24	0.23	0.46	9.31	0.21	.....	.....
0.208	0.077	+0.20	−0.30	30	0.38	0.00	11.07	0.74	0.117	.....
.....	0.047	−0.70	−0.70	25	0.00	0.60	11.70	0.29	0.180	.....
0.431	0.031	+2.10	+2.10	25	0.00	0.00	9.12	0.28	0.166	0.280
0.573	0.031	−0.60	−0.60	25	0.00	0.00	11.05	0.34	0.194	0.280
0.216	0.071	+1.30	+1.10	27	0.15	0.00	7.74	0.11	0.200	0.231
0.134	0.062	+2.30	+2.10	29	0.15	0.00	10.22	0.25	0.111	.....
0.231	0.024	+1.30	+1.10	30	0.15	0.00	8.84	0.02	0.027	0.151
0.327	0.046	+2.10	+1.60	29	0.38	0.00	10.78	0.27	0.048	.....
0.114	0.037	+0.40	+0.40	29	0.00	0.00	9.39	0.10	0.034	.....
0.179	0.000	+1.70	+1.40	28	0.24	0.00	9.12	0.20	0.124	0.28
0.193	0.200	±0.00	±0.00	.....	0.00	0.00	9.39	0.32	0.033	.....
.....	0.073	+0.80	+0.90	30	0.00	0.00	.....	.....	.....	.....
0.252	0.071	+0.30	+0.30	30	0.00	0.00	8.74	0.34	0.330	0.207
0.251	0.080	+1.05	+0.78	27	0.17	0.22	9.53	0.36	0.160	0.242
0.186	3.480	±0.00	±0.00	.....	0.00	0.00	0.00	0.83	0.124	.....
.....	0.626	+1.30	−2.50	28	2.92	2.80	9.30	[7] 1.13	.....	.....

rtion.
cilage made it impossible properly to determine specific gravity.

TABLE II.—*Analyses of the pulp of tunas.*

Collector's number.	Date of analysis.	Locality.	Scientific name.	Common name.	Number per pound.	Average weight.	Rind.	Seed.	Refuse.	Edible portion.	Composition of edible portion.																	
											Total solids.	Soluble solids.	Specific gravity of juice.	Total solids in juice.	Total proteids.[1]	Albuminoids (N×6.25).	Amids (N×4.25).	Water-soluble proteids (N×4.25).	Acids expressed as H_2SO_4.	Polarizations.		Temperature.	Sucrose by polarization.	Sucrose by reduction.	Total sugars as dextrose (Allihn).	Ash in soluble solids.	Alkalinity of ash as K_2CO_3.	Alcohol precipitate.
																				Direct.	Invert.							
		TEXAS SAMPLES.																										
2	1905	San Antonio	Opuntia lindheimeri	Prickly pear; nopal	6.30	71.63	66.32	5.41	71.73	28.27	7.78	7.57	1.033	7.98	0.201	0.058	0.143	0.156	0.700	+0.300	−0.400	30	0.53	0.00	7.18	0.17	0.027	.....
3	1906	.....do	.....do	.....do	18.12	25.00	67.00	7.80	74.80	25.20	5.68	.....	.....	.....	0.480	.....	.....	.....	1.180	.....	.....	.....	.....	.....	0.85	.....	.....	.....
4	1906	.....do	.....do	.....do	13.78	32.96	58.00	8.71	66.71	33.29	7.80	7.27	1.030	7.27	0.284	.....	.....	0.284	0.880	−0.500	−0.700	26	0.15	0.41	5.24	0.42	0.276	0.394
5	1906	.....do	.....do	.....do	21.57	21.00	61.90	6.19	68.09	31.91	7.13	.....	.....	.....	0.459	.....	.....	.....	.....	±0.00	±0.00	24	0.00	0.00	1.41	.....	.....	.....
6	1906	.....do	.....do	.....do	17.07	26.54	66.90	9.57	76.47	23.53	5.33	.....	.....	.....	.....	.....	.....	.....	2.150	.....	.....	.....	.....	.....	0.00	.....	.....	.....
		Average			15.37	35.43	64.02	7.54	71.56	28.44	6.74	7.42	1.032	7.63	0.356	0.058	0.143	0.220	1.228	−0.067	−0.367	27	0.23	0.14	2.94	0.30	0.152	0.394
		MEXICAN SAMPLES.																										
8051	Aug. 11, 1905	Alonzo	Opuntia streptacantha	Tuna cardona	10.34	43.83	58.90	6.30	65.20	34.80	11.47	11.25	1.040	9.62	0.346	0.078	0.268	0.252	.....	+2.00	.....	.....	.....	0.35	9.76	0.37	0.033	.....
8099	Sept. 6, 1905	Aguascalientes	.....do	.....do	9.06	50.00	42.66	3.32	45.98	54.02	13.70	13.52	1.050	11.92	0.312	0.104	0.208	0.268	0.038	+1.10	+0.700	29	0.30	0.00	11.05	0.24	0.062	0.200
[2] 8099	Sept. 16, 1905	.....do	.....do	.....do	9.24	49.00	51.53	3.39	54.92	45.08	.....	.....	.....	.....	.....	.....	.....	.....	.....	+2.40	+2.400	30	0.00	0.00	8.84	.....	.....	.....
[3] 8099	Sept. 26, 1905	.....do	.....do	.....do	9.64	47.00	61.70	2.95	64.65	35.35	12.10	11.99	1.049	11.69	0.501	0.174	0.327	0.149	0.076	+2.30	+2.000	29	0.15	0.00	9.95	.....	.....	0.200
8099	Sept. 10, 1906	.....do	.....do	.....do	7.48	60.50	48.92	3.39	52.31	47.69	14.08	13.78	1.053	12.60	.....	.....	.....	.....	0.040	+1.50	+1.100	28	0.31	0.58	11.05	0.23	0.140	0.394
[2] 8099	Sept. 20, 1906	.....do	.....do	.....do	8.52	53.15	50.00	3.25	53.25	46.75	.....	.....	.....	.....	.....	.....	.....	.....	.....	+1.20	+0.300	20	0.68	1.04	9.07	.....	.....	.....
[3] 8099	Sept. 30, 1906	.....do	.....do	.....do	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.69	10.44	.....	.....	.....
8143	Sept. 20, 1905	Gutierrez	Opuntia leucotricha	Tuna durasnilla blanca	10.60	42.90	60.50	4.90	65.40	34.60	10.39	10.22	1.033	7.98	0.186	0.070	0.116	0.164	0.320	+1.00	+1.000	25	0.00	0.00	8.84	0.30	0.460	0.180
8150	Sept. 22, 1905	Zacatecas	.....do	Tuna durasnilla colorada	11.10	40.60	69.16	2.96	72.12	27.88	10.00	9.95	1.036	8.68	0.148	0.088	0.060	0.100	0.079	+0.30	+0.300	25	0.00	0.00	8.84	0.27	0.170	0.210
8545	Sept. 19, 1906	.....do	.....do	Tuna durasnilla blanca	14.30	31.67	60.30	5.80	66.11	33.89	.....	.....	1.030	7.27	.....	.....	.....	.....	.....	+0.80	−0.100	24	0.68	0.26	7.08	.....	.....	.....
8146	Sept. 21, 1905	.....do	Opuntia sp	Tuna blanca	5.90	76.30	40.63	3.93	44.56	55.44	10.81	9.60	1.043	10.31	0.427	0.079	0.348	0.387	0.078	+1.80	+1.60	26	0.15	1.58	8.29	0.20	0.120	0.250
8547	Sept. 19, 1906	.....do	.....do	.....do	3.66	123.75	41.41	3.95	45.36	54.64	12.35	.....	1.037	8.92	.....	.....	.....	.....	.....	+1.00	+0.50	24	0.38	0.32	8.99	.....	.....	.....
8141	Sept. 19, 1905	.....do	.....do	Tuna pachona	9.40	48.20	41.49	3.32	44.81	55.19	11.81	11.66	1.051	12.15	0.326	0.088	0.238	0.342	0.062	+0.90	+0.80	26	0.08	0.00	9.12	0.20	0.180	0.280
8546	Sept. 19, 1906	.....do	.....do	.....do	9.70	46.70	45.61	3.84	49.45	50.55	12.16	.....	1.046	11.00	.....	.....	.....	.....	.....	−0.20	−0.50	24	0.23	0.46	9.31	0.21	.....	.....
8057	Aug. 12, 1905	San Luis Potosi	.....do	Tuna amarilla	4.80	94.00	46.15	5.14	51.29	48.71	13.56	12.67	1.054	12.15	0.327	0.104	0.223	0.208	0.077	+0.20	−0.30	30	0.38	0.00	11.07	0.74	0.117	.....
8485	Sept. 10, 1906	Aguascalientes	.....do	.....do	2.76	164.00	35.36	4.27	39.63	60.37	13.31	13.28	1.051	12.15	0.200	.....	.....	.....	0.047	−0.70	−0.70	25	0.00	0.00	11.70	0.29	0.180	.....
8142	Sept. 20, 1905	Zacatecas	.....do	Tuna naranjada	6.10	74.00	32.43	5.00	37.43	62.57	12.92	12.88	1.047	11.23	0.484	0.088	0.396	0.431	0.031	+2.10	+2.10	25	0.00	0.00	9.12	0.28	0.166	0.280
8140	Sept. 19, 1905	.....do	Opuntia larreyi	Tuna camuesa	2.80	163.84	42.42	1.52	43.94	56.06	11.90	11.72	1.044	10.54	0.596	0.066	0.530	0.573	0.031	−0.60	−0.60	25	0.00	0.00	11.05	0.34	0.194	0.280
8135	Sept. 15, 1905	Aguascalientes	Opuntia sp	Tuna joconoxtle	11.00	41.17	68.46	4.59	73.05	26.95	7.66	7.33	1.034	8.21	0.587	0.139	0.448	0.216	0.071	+1.30	+1.10	27	0.15	0.00	7.74	0.11	0.200	0.231
8134	Sept. 16, 1905	.....do	.....do	Tuna vinatera	18.80	24.08	44.85	4.98	49.83	50.17	12.14	11.07	1.048	11.46	0.223	0.104	0.119	0.134	0.062	+2.30	+2.10	29	0.15	0.00	10.22	0.25	0.111	.....
8119	Sept. 12, 1905	Dublan	.....do	Tuna agua-mielilla	14.70	30.84	57.72	4.28	62.00	38.00	10.98	10.78	1.040	9.62	0.891	0.052	0.839	0.231	0.024	+1.30	+1.10	30	0.15	0.00	8.84	0.02	0.027	0.151
8102	Sept. 1, 1905	Encarnacion	.....do	Tuna leonera	15.10	30.00	68.66	3.33	71.99	28.01	13.21	12.89	1.052	12.38	0.364	0.156	0.208	0.327	0.046	+2.10	+1.60	29	0.38	0.00	10.78	0.27	0.048	.....
8100	Aug. 29, 1905	Aguascalientes	.....do	Tuna chaveña	6.80	66.50	71.72	2.20	73.92	26.08	10.57	10.42	1.039	9.38	0.253	0.104	0.149	0.114	0.037	+0.40	+0.40	29	0.00	0.00	9.39	0.10	0.034	.....
8136	Sept. 15, 1905	.....do	.....do	.....do	8.20	55.27	74.91	3.26	78.17	21.83	11.17	11.10	1.041	9.85	0.377	0.139	0.238	0.179	0.0 0	+1.70	+1.40	28	0.24	0.00	9.12	0.20	0.124	0.28
8065a	Aug. 18, 1905	Ypiña	Opuntia robusta	Tuna tapona	6.20	73.60	52.31	4.48	56.79	43.21	12.97	12.77	1.048	11.46	0.213	0.139	0.074	0.193	0.2 0	±0.00	±0.00	.....	.....	0.00	9.39	0.32	0.033	.....
8065b	Aug. 26, 1905	Riverside (Cal.)	.....do(?)	.....do	2.20	210.60	47.48	3.01	50.49	49.51	.....	.....	1.050	11.92	.....	.....	.....	.....	0.073	+0.90	+0.90	30	0.00	0.00	.....	.....	.....	.....
8050	Aug. 9, 1905	San Luis Potosi	Opuntia sp	Tuna teca	4.20	109.00	43.60	4.50	48.10	51.90	11.21	10.97	1.048	11.46	0.334	0.155	0.179	0.252	0.071	+0.30	+0.30	30	0.00	0.00	8.74	0.34	0.330	0.207
		Average			8.56	71.17	52.26	3.92	56.18	42.26	11.84	11.54	1.044	10.58	0.377	0.107	0.276	0.251	0.080	+1.05	+0.78	27	0.17	0.22	9.53	0.36	0.160	0.242
8035	Aug. 9, 1905	San Luis Potosi	Opuntia imbricata	Tuna juell	8.80	51.56	31.45	9.68	41.13	58.87	7.57	5.54	[6] 0.903	.....	0.363	0.155	0.208	0.186	3.480	±0.00	±0.00	.....	0.00	0.00	0.00	0.83	0.124	.....
5	.....	Agricultural College, N. Mex	Echinocereus stramineus	Pitulla	24.71	81.33	30.83	([5])	30.83	69.17	18.14	.....	.....	.....	.....	.....	.....	.....	0.626	+1.30	−2.50	28	2.92	2.80	9.30	[7] 1.13	.....	.....

[1] Obtained from sum of albuminoids and amids.
[2] Ten days after gathering.
[3] Twenty days after gathering.
[4] Omitted from average; not Mexican sample.
[5] Small, included with edible portion.
[6] Presence of so much plant mucilage made it impossible properly to determine specific gravity.
[7] Total ash.

than 75 seeds, while others contained as many as 400. The average weight for the wild forms from Texas was 7.54 per cent of the whole fruits, while in one sample of a cultivated Mexican variety there was only 1.52 per cent of seeds. The larger cultivated fruits always have proportionally fewer seeds, and it may be that in time cultivation and selection will still further reduce the number.

THE REFUSE.

The waste in eating the cactus fruit consists of the seeds and such part of the rind as is rejected—when the rind is eaten, the waste is the seed with only that part of the rind which is lost in peeling the fruit. Since such a large percentage is rind, the waste is very large when this is rejected. In one variety, tuna chaveña (No. 8136), it amounted to 78.17 per cent. The fruit having the smallest amount of waste of all the prickly pears was No. 8142, tuna naranjada—only 37.43 per cent. The average for the Mexican samples was 56.18 per cent. The samples received from San Antonio, Tex., *Opuntia lindheimeri*, averaged 71.56 per cent of refuse.

The watermelon has 59.4 per cent waste; the muskmelon, 50 per cent; bananas, 35 per cent; oranges, 27 per cent; apples, 25 per cent, and pears, 10 per cent.[a] Thus it will be seen that the tunas, when the rind is rejected, have about the same proportion of refuse as the melon, and when the rind is eaten about the same as other fruits.

HARVESTING THE TUNA.

The method of harvesting the tuna is influenced both by the variety gathered and the purposes for which the crop is to be used.

HARVESTING FOR IMMEDIATE CONSUMPTION.

It is common for the peon to get a large portion of his living during the tuna season from the plants as they stand in the field. (Pl. II, fig. 1.) A large part of the crop is therefore consumed directly from the plants. The object of the picker in such cases is to get the edible pulp separated from the remainder of the fruit with as little difficulty as possible. A sharp knife is used to make an incision across the top of the fruit and curving down on one side to, or nearly to, the attachment. Then the thumb and forefinger of the left hand are forced down between the rind and the pulp, loosening the latter and forcing it upward, when it is caught between the thumb and the index and middle fingers and removed without coming in contact with the small spines at all. The incision is made only to such a depth as will expose the pulp, and none of the rind is removed from the trees. Of course

[a] U. S. Dept. Agr., Office of Experiment Stations, Bul. 28.

this method applies only to such fruits as are in reach of the picker and is practiced by those who eat as they gather in the field. The method of securing the tunas growing beyond reach of a man standing upon the ground is described later.

GATHERING CULTIVATED FORMS.

As stated elsewhere, the mansas or tame forms are not disfigured by cutting the joints as are the wild ones. The vast majority of the cultivated tunas is produced beyond the reach of a man on the ground, and these are collected with a long pole (usually bamboo). The end of this pole is divided into three or four equal segments, which are held apart by a wooden plug secured firmly in place by thongs of rawhide or maguey (Agave) fiber. This makes a conical receptacle in the end of the pole which is thrust around the tuna, the latter being removed by twisting the pole. In this process of gathering, the fruit is more or less injured either by the end of the stick itself or by the wrenching process used in loosening it from the tree. Sometimes the fibers entering the tuna from the joint are twisted off, leaving a lacerated hole in the end of the fruit. At other times the base of the tuna itself is twisted off. It is evident that fruit injured in this way will not keep long. A large part of the fruit of the cultivated forms upon the markets, however, is gathered in this way.

GATHERING WILD FORMS.

Whenever the preservation of the plants is not an important consideration, the Mexican gathers the tunas which are beyond his reach with a gancho (hook), made by fastening a strong knife blade at right angles to a long pole. (See Pl. II, fig. 2.) With this he cuts the joint nearly off, thrusts the point of the gancho into the severed portion, and lowers it to the ground. Commonly but very little attention is paid to the quantity cut from a plant, the place of the incision depending upon the number and distribution of the tunas. Often two or three joints are taken off together, but more commonly only that portion of the one containing tunas is removed.

After the joints have been lowered to the ground in this way the pulp is removed as previously described, the operator either standing in a bent-over position, with one foot upon the segment of the joint, or kneeling upon one knee. (Pl. II, fig. 2.)

GATHERING FOR THE MARKET.

When tunas are desired for the market, for shipment, or for storage in a fresh condition, more care is exercised in picking them. Instead of tearing or twisting them from the joints, they are carefully cut off

with a sharp knife. The fruit is taken between the thumb and the forefinger and middle finger of the left hand and pushed to one side slightly, when with the point of a knife its connection with the stem is severed. The difficulty of this operation may not be apparent to the reader unfamiliar with the small spines with which the fruits are protected. The handling must be very carefully done. The native becomes so adept that he grasps the fruit between the cushions of spines with little likelihood of being injured. Owing to the fact that there is no appreciable fruit stem, as there is in the apple, peach, and pear, it is difficult to remove the fruits from the trees without injuring them. Italian shipments upon the markets of this country usually have a small portion of the joint attached to the fruit. It is usually less difficult to collect tunas in this way; but the small piece of joint probably gives no advantage over a perfect fruit removed without it. The difficulty in picking without injury varies with different varieties and in the same variety under different conditions of development. A plump fruit is much more difficult to remove without injury than one which is shriveled, as will be readily apparent. Such forms as the amarilla, naranchada, camuesa, etc., which are shaped somewhat like the common pear, are more easily picked than the more nearly globular forms, such as cardona, chaveña, etc.

EFFECTS OF CUTTING OFF THE JOINTS IN HARVESTING.

Personal observations of the thickets and the opinions expressed by the more intelligent people lead us to believe that, on the whole, cutting off the joints results in injury to the succeeding crop of tunas. Fruits are produced upon the last year's growth, and if this be very severely pruned, as is often the case when a large crop is harvested with the gancho, the growth the following season consists very largely of vegetative joints and not fruits; but the second year after a severe pruning a large crop of fruit is likely to be produced. In fact, the pruning is not wholly a bad practice, for the joints strewn over the ground often give rise to new plants, thereby extending the thickets.

THE KEEPING QUALITIES OF TUNAS.

Contrary to popular opinion, some tunas can be preserved in the fresh condition, if properly handled, about as long as the common fruits of the temperate zone. It is not at all uncommon to find the Italian forms upon the markets of the chief cities of this country in the autumn and early winter. These withstand transportation, besides two or three months in storage on this side of the ocean. The writers have had samples of yellow tunas of Italian origin obtained

upon the markets in Washintgon city remain in good condition in their possession for two months while subjected to the irregular temperatures of an ordinary living room.

Like all other fruits, different forms have different keeping qualities, and freshness is of longer duration when the picking is done before maturity than when dead ripe. Cardonas will remain good for twelve to fifteen days upon the open markets of Mexico after being picked and carried on burros a distance of 10 to 20 miles. The mansa forms keep longer if cut instead of being twisted or pulled off. The best keepers are without doubt some of the forms of joconoxtle and chaveña. The latter is the one commonly kept over winter in the region of Aguascalientes. The packing of this species is a regular business, and it may be found upon the markets as late as the 1st of May. It is one of the latest tunas to mature in the fall and has a comparatively thick, firm rind, well adapted for storage. On the whole, it may be said that tunas are easily injured, and consequently much care is necessary in handling them when they are intended for packing. They must also be well aerated in storage, which is true of all fruits.

At the present time there is quite an extensive shipment of tunas by rail from place to place in Mexico. The writers happened to be in Torreon on a Sunday during September, 1906, when a carload was brought from near Aguascalientes. It contained cardonas mostly, but also some fafayucas, amarillas, naranchadas, and durasnillas. They were shipped loose in an ordinary box car, piled upon the bottom of the car to a depth of about 2 feet. They are commonly shipped packed in crates with straw, the crate being usually a little smaller than our common orange boxes.

The crate is almost invariably used in bringing tunas to market on the backs of burros. When intended for immediate market use they are emptied in piles upon the ground, those not exposed for sale being covered with green herbage or old cloths and kept at a lower temperature than the surrounding atmosphere by the evaporation of water sprinkled over them from time to time. Handled in this way they keep in the open air for ten to twenty days.

Some species, the chaveñas especially, in the vicinity of Aguascalientes are regularly kept over winter in the fresh condition, and one may find some of the various species and varieties in the market places during practically the entire year. From late May to early December there are fresh forms constantly found, and even in the spring some of the forms of joconoxtle, which are eaten only after being cooked, may be found upon the trees. However, the majority of those upon the markets after December have been packed. Around

Aguascalientes these are almost invariably chaveñas which have been put in storage. They are spread in thin layers, alternating with layers of straw or old hay in a dry, airy place. Handled in this way they will keep from October or November to the 1st of May.

MACHINERY USED IN MAKING TUNA PRODUCTS.

It is scarcely necessary to state that all of the appliances used in the manufacture of tuna products are of the most primitive nature, simple and crude but often exhibiting a great deal of skill and ingenuity in the use of inexpensive materials at hand which might not be recognized as at all suitable by people accustomed to the use of machinery. It must be remembered that the processes described here are essentially those of the primitive peoples of the Republic of Mexico. They are processes which have been followed in all essential particulars since Cortez first landed, and how long before no one knows. It is said that the same processes are in vogue to-day as then, with but slight modifications.

It is a common practice for a suitable number of people to establish a camp in the prickly pear thickets late in the season for the purpose of manufacturing queso and the other products. A factory and a few rude huts are quickly thrown up, giving shelter to the workers as well as to the manufactured products. We have seen factories consisting of a small adobe building of one room about 25 feet long by 15 feet wide, thatched with the leaves of the yucca (Pl. V, fig. 1). They usually contain one or two kettles, generally of copper, although pottery is sometimes used, one or two troughs hewn out of willow, three or four earthenware tubs, and smaller earthenware vessels in which the liquids and plastic materials are handled. The kettles are set in the ground up to their handles, on a slightly elevated side of the room, over a rude furnace consisting of earth, rock, and adobe. Besides the kettles, there are in the rear of the room two seeders of tin, supported upon a frame. On the left of the factory is a large trough hewn from the trunk of a willow, and in the rear of the room is another smaller one of the same material. Under the seeders are earthenware tubs. The bottom of an olla (earthenware urn) projects above the first kettle. The kettles are reenforced to a height of about 18 inches by slabs of wood cut from the trunk of a large yucca. These are tightly fitted together and the whole tied with a rope made of agave fiber. Some of the yucca wood is macerated and used to chink in around the top of the kettle to make it tight. The kettles are about 20 inches deep and 3½ feet in diameter.

The seeder consists of a tin vessel with a short conical base having a pivot support in the center to receive an axial shaft upon which are

hung paddle-like wings, shown in more detail in Plate IV, figure 1. This axis with the paddles is operated by a crank, as shown in the illustration. The tin vessel is perforated by nail holes of such size that they will not allow the seeds to pass through.

The furnace is exceedingly crude and consists of a fire pit under the kettles, and somewhere a smoke flue.

TUNA PRODUCTS.

Of the numerous products manufactured from the prickly pear, only those which appear to be the most important have been selected for discussion. To consider all of the products would necessitate the use of more space than can be devoted to the subject. Those enumerated will give a very fair idea of the importance of the crop upon the highlands of Mexico.

In detailing the methods of manufacture it is realized that the descriptions given constitute simply the recipe used by the people in a certain locality. There may be variations in the methods employed in different sections, but the essential features of the processes do not differ. The methods here outlined are those employed in the vicinity of Villa Garcia, in the State of Zacatecas.

The tuna products are usually manufactured in the season when the fruit is thoroughly ripened. At any other time the business would not be as profitable; the labor of collecting would be much greater if done while the crop was only partially ripe. Again, there is less need for preservation of the valuable material so long as it remains in good condition upon the trees and may be eaten in the fresh state.

In the different manufacturing processes all available tunas may be used indiscriminately, but there are certain characteristics essential in certain products. Although the pickers usually gather all fruits of whatever species they can find, the prevailing material will be of one species usually best suited to the process.

The tunas may be divided into two great classes, based upon their condition when ripe. One group or class has pulp which when squeezed through a fine cloth gives a limpid liquid with most of the solid constituents in solution. To this group belong the more important of the mansas or cultivated forms, such as the amarilla, the naranchada, the blanca, the palo altena, the fafayuca, the camuesa, the ranchera, and the morada. The other class has fruits whose pulp when treated in the same manner yields an opaque liquid having much solid matter in suspension in a fine granular condition. The foremost of this group is the cardona, and with it should be classed the tapona, the agua-mielilla, the lionera, the pachona, and the opalilla. For the manufacture of queso, melcocha, and miel only those forms

are used which have solid or semisolid substances in suspension in their extracted juices. The members of the other group are more often used for drying.

Colonche may be manufactured from almost any of the species, but as a matter of fact it is seldom made from the mansas, because of the higher value of the fresh fruit. In practice, the species used in a locality is quite constant and the products manufactured are very pure, for one species usually predominates to such an extent as to necessitate its use to the exclusion of others. For instance, in the vicinity of San Luis Potosi and Aguascalientes the cardona predominates, while farther south the lionera, the agua-mielilla, and the artona are more prevalent. It is not economical to prepare the products from the large mansa forms until late in the season, and then they are usually dried. They command a better price when fresh, because the supply is rather limited.

Different colored species produce food products of different colors, as would be expected. The color for a given product from any species, however, may or may not be constant, for the process of manufacture may vary to such an extent as to change the color. This applies especially to such products as miel, melcocha, and queso, which have a somewhat complicated process of manufacture, are subjected to a considerable heat, and, in the case of the last especially, are modified by aeration and kneading after the boiling ceases. The boiled paste from the tuna cardona is almost black, and melcocha is consequently of the same color, but the queso is light brown. The tuna cardona, on the contrary, retains its red color through the boiling process and therefore makes red queso, which does not seem to be in much favor.

When tunas are gathered for manufacturing purposes, the pulp—the part ordinarily used—is removed in the field, as described elsewhere. On account of its exceedingly juicy nature it is gathered in earthenware vessels, or ollas, and taken into the factories in quantities of 50 to 75 pounds. The picker usually has the earthenware vessel strung across his shoulders by means of ropes of maguey (Agave) fiber. When the vessel is filled, it is delivered to the factory in a cart or the picker carries it if the factory is not too far away. Material delivered to the factories consists of the seedy pulp which is ready for the kettles or the seeders.

Analyses of several kinds of tuna products are given in Table III.

TABLE III.—*Analyses of some tuna products.*

Laboratory No.	Name of product.	Total solids.	Soluble solids.	Total proteids (N X6.25).	Water-soluble proteids (N X4.25).	Acids expressed as H_2SO_4.	Polarizations. Direct.	Polarizations. Invert.	Temperature.	Sucrose by polarization.	Sucrose by reduction.	Total sugar as dextrose (Allihn).	Ash in soluble solids.	Alkalinity of ash as K_2O.
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*			°*C.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
2356	Dried tunas (tunas pasadas)[1]	92.54	81.58	2.52	1.20	2.34	− 6.00	− 7.00	22	0.75	1.18	51.06	4.45	.....
[2]2357	Melcocha	86.64	84.46	2.41	1.28	0.54	+ 6.40	+ 5.80	26	0.46	0.00	63.35	4.70	1.24
[2]2357	Melcocha[3]	77.89	.....	.....	.....	.....	+ 4.20	+ 2.00	30	1.55	.....	64.16	.....	.....
[2]2358	Miel	68.98	68.65	3.06	1.19	0.26	+ 7.00	+ 4.50	22	1.88	0.00	61.47	1.19	0.62
[2]2359	Queso de tuna[4]	91.56	89.06	2.55	0.53	0.44	+14.00	+14.00	17	0.00	0.10	55.39	3.64	1.66
[2]2360	Queso de tuna[5]	86.09	83.87	2.22	1.21	0.51	+10.00	+ 9.00	22	0.75	0.10	55.48	2.96	1.66
2361	Concentrated pulp of Opuntia laevis (?)[6]	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.48	51.60	.....	.....

[1] Percentage of seed, 24.50. This was prepared from the tuna amarilla.
[2] Manufactured from the tuna cardona.
[3] Analyses made by Bureau of Chemistry, United States Department of Agriculture.
[4] Large sample from Hacienda Los Campos.
[5] Small sample from public markets at Aguascalientes.
[6] See page 62.

MIEL DE TUNA.

In the manufacture of miel de tuna the seeder is usually not employed. The peeled tunas are put in the kettles and boiled until the free seeds fall to the bottom. This requires usually about two hours, fresh material being added from time to time as the water evaporates. The seeds are removed with a sieve and the sirup is returned to the fire and boiled slowly for two or three hours more, or until it approaches the consistency of honey. It is then poured into wooden troughs, where it is thoroughly stirred with wooden paddles until completely cooled. After setting for twelve to twenty-four hours it is packed away in bottles or earthenware jugs. It may be kept about the same as molasses and is said to remain in good condition indefinitely. After a time, however, it candies and becomes difficult to handle.

The method of cooling is considered very important in the manufacture of this product as well as in the manufacture of melcocha and queso, for if the material is allowed to cool without stirring it is believed to have a tendency to sour. After it has cooled there is said to be no further danger of deterioration. The only change which appears to take place thereafter is crystallization, which begins rather soon and is said to continue for about two years, until a completely candied mass is formed. Upon the large haciendas away from the towns this sells for from 15 to 20 cents a liter (about 1 quart).

MELCOCHA.

In the manufacture of melcocha peeled tunas are put in the machine and seeded. The kettles are filled two-thirds full of juice, which is

boiled upon a brisk fire for about three-quarters of an hour, when more juice is added and the boiling continued. The foam arising from the boiling is very great when the sirup is thin, but as it thickens this becomes less; then more of the fresh juice is added to thin it until, little by little, the supply is all used up. This takes four or five hours in all. The material is then kept warm by banking the fire. After this it is kept in such a condition that it thickens very gradually for one or two hours more, the object now being to keep the evaporation constant and low until the proper consistency is reached. When a spoonful can be dipped up and the material will not run out when turned upside down, the process of evaporation is stopped and all fire is removed from the furnace.

The process of the manufacture of melcocha is exceedingly variable. The one detailed above is that interpreted to us by Señor Enrique Guerra in 1905. In 1906 other persons upon the same hacienda prepared melcocha somewhat differently.

Invariably the puddled paste from which queso is made is called melcocha also, and often this is preserved for future use with no kneading or other preparation except packing away in suitable receptacles, as described elsewhere. The only difference between melcocha and queso in that case consists in the kneading and puddling which the paste gets after being cooled, the melcocha being simply unkneaded queso. The two products might be likened to taffy in the different stages of its manufacture, the taffy corresponding to the queso and the cooled sugar or molasses before being pulled to the melcocha.

After the evaporation is stopped, the melcocha is poured into a trough, as in the case of miel, and worked with wooden paddles very rapidly in order that it may cool as quickly as possible. When the temperature is reduced so that it is not uncomfortable to the touch, the vessel is covered and left until the next day, or it may be left two or three days. The best way, it is said, is to puddle upon a stone or wooden table twenty-four hours after evaporation has discontinued. The rule here is to "strike" the "dough" 100 times on a stone, the whole lump being raised above the head and then dropped forcibly 100 times. During this process flavoring matter, almonds, etc., are sometimes added to the product, but usually nothing is added to the concentrated juice.

Crystallization begins in melcocha within a month or six weeks after manufacture and continues indefinitely, the material becoming more and more candied with time, like miel.

Melcocha may be kept in earthen jars with wide mouths, which is the common method of preservation. A poorer way is to preserve without puddling. In this case, about two tablespoonfuls are put in a

corn husk and covered completely and as tightly as possible with this kind of covering. In this form it is a common article upon the market places in the larger cities, and this quantity usually sells for 1 cent. The price of melcocha put up in quantity in earthenware jars is from $1.50 to $2 per arroba (25 pounds).

QUESO DE TUNA.

The queso, or cheese, of the tuna is made the same as melcocha, except that the evaporation is carried a little further or until the cooled material will not leave the spoon when it is shaken. The puddling is also more thoroughly done. The rule here is to "strike" 150 or 200 times upon a flat stone or wooden table. Queso, while so similar to melcocha, never crystallizes, although the evaporation is carried but little further.

After puddling the product is put in any shape desired. It is commonly shaped in small hoops of white pine or willow about 3 inches in diameter or in larger boxes dovetailed at the corners so they can be removed in pieces. The first method gives the product the form of the common cottage cheese found upon the markets, and it is from this that it receives its name queso de tuna, or cheese of the tuna. These molds are moistened just before the material is packed into them to be shaped. They are then removed immediately. The queso sets perfectly in from one to two hours. It is a common practice at the larger haciendas, where a first-class product is desired, to cover the queso with tin foil to preserve the color and prevent evaporation. No other changes appear to take place in this product.

Queso will keep indefinitely if put away in a dry place to prevent molding. However, it gets harder and harder from loss of moisture as time goes on. Covering with tin foil delays hardening and prevents darkening to some extent. The more puddling or kneading the material gets in its manufacture the harder it becomes and the lighter is its color. To avoid the labor of puddling, it is a common practice to get rid of the natural dark color by adding dyes. This leaves the queso soft and gives to the trade the color that is pleasing. Beet, carrot, and other vegetable juices are used for this purpose.

Sometimes one will find queso and melcocha packed in vessels in alternate layers. After a few months the melcocha is candied to a considerable extent, while the queso remains soft and plastic, giving what is considered a very desirable product.

The treatment of the paste after leaving the kettles is one of aeration and apparently does not differ essentially in effect upon the product from the process of pulling taffy. Although it would seem that the details of the process might be quite varied, wherever the writers have seen queso puddled the method has always been the

same. A batch of the paste consisting of 10 to 20 pounds is placed upon a flat rock which has been previously moistened with water. The paste is gathered into a compact mass by hand and the whole raised above the head of the operator and dropped, or really thrown forcibly down upon the rock again. The edges of the flattened mass are gathered together again and the process is repeated many times. Usually two persons work by turns, for the labor is very exhausting, the mass of paste being quite heavy and the movements necessary to handle the mass properly being rapid and vigorous.

COLONCHE.

In the preparation of colonche, which is a fermented drink, the pulp, including the seeds, is boiled slowly two or three hours, fresh material being added from time to time as evaporation goes on. The whole mass is then strained and the liquid set away to cool. Usually a little old colonche is added to start fermentation. This beverage is used from the time fermentation begins up to twenty days or more thereafter. The longer it stands the more violent is its intoxicating effect. In some cases the seeds are removed by the seed extractor and the juice is boiled, as before. Sometimes, but not so often as formerly, old colonche is distilled into an alcoholic beverage.

It was a common practice a few years ago to distill the fermented peelings of the tuna, but the practice has not been successful because of the ill effects which the product is said to have. The natives say it produces violent headaches, and for this reason it has been almost entirely supplanted by mescal, tequilla, and other maguey (Agave) products which produce less deleterious effects.

No successful method seems to have been devised for the preservation of colonche. Some have tried to bottle it, but without success. It is quite probable that the fresh juice could be preserved by boiling, thus killing all germs, and then hermetically sealing it in vessels in much the same way as fresh fruits are preserved in this country. The failures appear to the writers to be due to imperfect methods of sterilization.

RELATION OF TUNAS TO FINISHED PRODUCT.

It is seldom that one, by talking to the men who make the queso, can get any idea of the amount of boiling and evaporating to which the tuna juice is subjected. Fortunately, in 1906, an opportunity was had to visit Los Campos in season. Through the kindness of Señor Enrique Guerra a day was spent at a queso factory and notes were secured upon the work carried on that day, including the entire process from the charging of the kettles in the morning to the puddling in the evening. The next morning the weighing and kneading of the paste were also witnessed.

At 6 o'clock in the morning of the day spent at the factory the kettles were charged with 65 gallons of the juice of the tuna cardona, a portion of which had been seeded the night before. A brisk fire of wood of the same species of prickly pear was started at the same time. During the day 25 gallons more of the juice were added as evaporation proceeded. The evaporation was carried on very slowly and somewhat irregularly until 8 o'clock in the evening. But little attention was paid to the kettles until toward evening, when the juice was constantly stirred. The juice was secured from 150 gallons of peeled tunas from which the rind had been completely removed, the shrinkage in seeding being very largely due to the bulky seed. These, however, it was impossible to weigh. The melcocha, which was kneaded into queso the next day, measured 12 gallons and weighed 130 pounds. These figures are sufficiently exact for ordinary computations upon these processes.

The relation of rind to pulp and seed in the tuna cardona as determined by our laboratory investigations is as 42.66 to 57.34. In the above charge of the kettles, therefore, the tunas, if they had been picked in the field, rind and all, would have measured about 261.66 gallons, yielding 150 gallons of tunas with the rind removed, which when seeded gave 90 gallons of juice. This when boiled gave 12 gallons of queso, as previously stated.

These figures apply only to the tuna cardona. The proportions might be very different for another species, but the amount of queso prepared from any other species is small. The cardona is preeminently the tuna for the manufacture of queso. It is a native species of average size, weighing about $1\frac{1}{2}$ ounces. It is only one-half to one-fourth the size of many of the cultivated forms.

DRIED TUNAS (TUNAS PASADAS; TUNAS SECAS).

The native Mexican exhibits a great deal of dexterity in the use of the knife in the preparation of the tuna to be dried. The thin outer skin of the fruit is so impervious to moisture that evaporation does not take place rapidly, and the fruit dries very slowly until this skin is removed. At the same time, because of the small amount of pulp and the large amount of juice, it is not a good plan to slice the fruit as apples are sliced. The plan followed is to peel very thinly and dry the pulp and rind intact. The tuna to be peeled is grasped with the thumb and middle finger of the left hand and with a sharp knife the epidermis is literally whittled off in small pieces almost as thin as paper. The operator saves all of the rind he can, taking off only the thin, hard epidermal covering, together with the areoles containing the spicules. The flower scar is left unmolested to dry upon the fruit. When peeled the fruits are sun dried upon a latticework of switches tied together with maguey (Agave) fiber or narrow strips of raw-

hide (Pl. III, fig. 2). The drying occupies from ten to fifteen days, when a yellow deposit, consisting probably in large part of crystals of dextrose incased in a covering of gum, plant mucilage, and possibly some uncrystallizable levulose, completely covers the outside of the fruits. They are then packed in woven rush bags, and in this condition are said to keep quite as well as other dried fruits. An attempt is made to get the outside thoroughly dried, but there is a great deal of moisture left in the pulp. After being packed loosely in a box for six months the pulp is still quite pasty and on the whole little drier than fresh dates as ordinarily found upon the markets. When kept in large quantities, tightly packed, the evaporation is, of course, not as great.

Considerable dexterity is exhibited by the operators in preparing the tunas for drying. The writers had the good fortune to observe the process in Montesa in the State of Zacatecas. Plate III, figure 1, tells better than words the attitude of the operator in peeling tunas. The fruit is held between the thumb and middle finger of the left hand, the thumb resting on the flower scar, and with a sharp knife in the right hand the epidermis is whittled off. The movements, contrary to what one would expect, are comparatively simple, the right hand moving the knife rapidly in one plane, the left holding the tuna between the thumb and middle finger, the index and third fingers rolling it on its axis. It makes two revolutions before it is completely divested of its epidermis. During the first revolution the epidermis is removed from the upper portion; then the fruit is tilted slightly as it revolves slowly, and the epidermis is removed from the lower half during the second revolution on its axis. The epidermis is thus removed in small very thin pieces. Before being peeled the fruit is brushed to remove the spicules. The operator shown in Plate III, figure 1, was timed repeatedly to determine the speed at which he worked. A fruit was peeled with from 28 to 35 strokes of the knife and in the remarkably short space of ten seconds.

At times a small stick about the size of a lead pencil is thrust into the proximal end of the tuna after it is peeled. It is then squeezed between the fingers to express as much of the juice as possible. This shortens the drying period three or four days, but much valuable material is, of course, lost, and the product prepared in this way is of inferior quality.

Cartons in which the dry tunas are packed contain about an arroba (25 pounds), or 600 dry tunas, for which the producer realizes from $1.50 to $2.50, depending upon the character of the crop.

Usually dry tunas are prepared from the white and yellow mansa forms, such as the amarilla, the naranjada, the fafayuca, the palo altena, the blanca, the teca, etc. The wild forms, such as the car-

dona, the pachona, the agua-mielilla, etc., are too small and contain relatively more spicules, both of which characters are objectionable. Again, the red species dry almost black and are consequently not nearly as attractive in the finished product as the lighter colored varieties.

METHODS USED IN ANALYSES OF TUNAS.

The methods of analyses which were used in this work are for the most part those of the Association of Official Agricultural Chemists.[a] In some cases the nature of the work seemed to demand a modification of these methods, and the scheme as used in the laboratory for the determination of each constituent is briefly outlined below.

(1) *Average weight.*—Weigh eight or ten average-sized fruits and divide the total weight by the number taken.

(2) *Percentage of rind.*—Remove the rind from the fruit by cutting off each end just through to the pulp, then cutting once lengthwise through the rind to the pulp, and then peeling back the rind. A distinct division usually exists between pulp and rind, rendering their separation easy. Calculate the percentage from the average weight of the rind and fruits taken.

(3) *Percentage of seed.*—With the hands squeeze the pulp obtained by the method explained in the preceding paragraph through a piece of stout, thin muslin. By this means practically all but the seed is forced through the meshes of the cloth. After washing with water, dry the seed on the water bath and weigh. Calculate the percentage from the average weight of the seed and fruits taken.

(4) *Percentage of refuse.*—The percentage of total refuse represents the sum of the average weight of seed and of rind divided by the average weight of fruits taken.

(5) *Percentage of edible portion.*—The difference between 100 and the total refuse represents the edible portion.

(6) *Percentage of total solids.*—Place 20 grams of the fresh pulp obtained by process No. 3 in a flat-bottomed dish which contains from 4 to 5 grams of freshly-ignited asbestos. Dry to constant weight in a water-jacketed vacuum oven at 70° C., and calculate the total solids.

(7) *Insoluble solids.*—Use Kremla's method as modified and described in Bulletin No. 66 of the Bureau of Chemistry, page 13.

(8) *Specific gravity of the juice.*—Filter some of the pulp obtained by process No. 3 through a piece of thin cloth, and determine its specific gravity by means of a Westphal balance. Determine the total solids of the juice from its specific gravity by the rules given in Bulletin No. 65 of the Bureau of Chemistry, Table IV, page 32.

(9) *Total nitrogen.*—Determine the nitrogen in 10 grams of fruit by the Kjeldahl method. The results obtained are used for the calculation of amids. The total proteids are the sum of the albuminoids and amids.

(10) *Albuminoids.*—Determine the albuminoid nitrogen in 10 grams of the fruit by the method of Stutzer as given in Bulletin No. 46 of the Bureau of Chemistry, revised edition, page 24. Multiply the nitrogen by 6.25 for the albuminoids.

(11) *Amids.*—Subtract the nitrogen of the albuminoids from the total nitrogen, and multiply the remainder by 4.25.

(12) *Acids.*—Take from 10 to 30 grams of the pulp, or better 100 c. c. (10 grams) of filtrate from the insoluble solids obtained by process No. 7, and titrate with N/10 potassium hydroxid. When the juice is highly colored its own coloring matter will serve as an indicator of the end reaction; otherwise use phenolphthalein or cochineal (calculate to per cent H_2SO_4).

[a] U. S. Dept. Agr., Bureau of Chemistry, Buls. 65 and 66.

(13) *Polarization (direct).*—Weigh 26.048 grams of the fruit, transfer to a 100-c. c. flask, add 50 c. c. of water, from 3 to 5 c. c. of subacetate of lead, and about 10 c. c. of alumina cream to clarify. Make up to volume; then filter and polarize.

(14) *Polarization (invert).*—In a flask graduated to 50 and 55 c. c., place 50 c. c. of the clear solution prepared in accordance with process No. 13. Fill to the 55-c. c. mark with concentrated hydrochloric acid. Place the flask in the water bath and heat until the thermometer marks 68° C., requiring fifteen minutes in the heating. Remove and cool to room temperature; then polarize and note temperature. Calculate the percentage of sucrose by Clerget's formula, $S = \frac{(a-b)\ 100}{144 - \frac{T}{2}}$

(15) *Reducing sugars.*—Take 25 c. c. of the solution prepared for polarization as explained in process No. 13 and add sufficient sodium sulphate to precipitate the excess of subacetate of lead; then filter. Take an aliquot part (5 c. c.) of this filtrate containing not over 0.2 gram of reducing sugars, add to a beaker containing 25 c. c. each of Soxhlet's copper and alkaline tartrate solutions, and make volume about 100 c. c. with water. Heat the contents of the beaker over wire gauze with the flame so regulated that boiling begins in four minutes. Continue boiling for exactly two minutes, keeping the beaker covered with a watch glass. Without diluting, filter the cuprous oxid at once on a weighed asbestos felt in a Gooch crucible, using suction. Wash thoroughly with distilled water at 60° C., then with 10 c. c. of alcohol, and finally with 10 c. c. of ether. Dry for thirty minutes in a water oven at 100° C., cool in desiccator, and weigh as Cu_2O. Calculate sugars as dextrose from Allihn's table. Make correction for spontaneous precipitation of cuprous oxid.

The asbestos used is specially prepared by digesting with 1 to 3 hydrochloric acid for two or three days. Wash free of acid and digest for a similar period with a soda solution, after which treat for a few hours with hot alkaline copper tartrate solution of the strength employed in sugar determinations.[a] The asbestos is then washed free from alkali, finally digested with nitric acid for several hours, and after washing free from acid it is shaken up with water for use.[b]

(16) *Sucrose by reduction.*—Invert the same amount of solution described in process No. 13 as was used for reducing sugars, using hydrochloric acid in the same proportion for inversion as described under process No. 14, and invert in a similar manner. Neutralize with sodium hydroxid and determine total sugars as dextrose. Subtract from this the reducing sugars obtained by process No. 15 and multiply the difference by 0.95 for sucrose by reduction.

(17) *Ash in soluble solids.*—Treat 50 c. c. of the solution obtained by process No. 6, as outlined under Determination of Ash in Bulletin No. 66 of the Bureau of Chemistry, page 13.

(18) *Alkalinity of ash.*—Add in known amount an excess of N/2 hydrochloric acid to the dish of ash obtained by process No. 17. Add 1 c. c. of cochineal solution and titrate with N/10 potassium hydroxid. Calculate to K_2CO_3. One c. c. N/10 KOH= 0.00691 grams K_2CO_3.

(19) *Alcohol precipitate—vegetable mucilage, pectin, and salts of organic acids.*—Determine by the method given in Bulletin No. 66 of the Bureau of Chemistry, page 21.

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[a] Reducing sugars were calculated to dextrose in this work because an excess of dextrose over levulose appeared to be present in the tunas. Since the reducing power of dextrose in terms of other reducing sugars is known, these values can be converted into any form of reducing sugars desired by means of their dextrose ratios as given by C. A. Browne, jr., in the Journal of the American Chemical Society, Vol. XXVIII, No. 4.

[b] Munson and Walker. Journal of the American Chemical Society, Vol. XXVIII, No. 6, p. 666.

COMPOSITION OF TUNAS.

TOTAL SOLIDS.

The solid matter in the fruit is about the average of that found in other fruits, as may be seen by comparing Tables IV and V.

Like all other fruits, the quantity of solids differs for the different varieties, amounting to from 5.33 per cent in No. 6, San Antonio, *O. lindheimeri*, to 11.60 per cent in No. 8057, tuna amarilla. No. 5, Agricultural College, had a higher solid content than the latter, but is not comparable with the other fruits, because it is an Echinocereus, and the seeds were included with the other solids, they being edible in this group of the plants.

The amount of total solids in any fruit is not necessarily an indication of its value, though usually high solids indicate high soluble solids and a high sugar content, and the nutritive value of any fruit is dependent on the quantity of these. Since the solids of the tuna are practically all soluble in water and a large percentage of the soluble material is sugar, the percentage of total solids of this fruit is usually an index of its nutritive value, but this is not always the case. No. 5, San Antonio, for example, had 7.13 per cent of solids, but only 1.41 per cent of these solids was sugar. However, with most tunas, practically all of the total solids of the pulp exclusive of seeds are soluble, and a high percentage of the soluble portion is sugar. There are few fruits that will make as good a showing as the tunas in this respect. In many of the small-seeded fruits, like figs and strawberries, the seeds are included in the total solids, while in the others, like apples and pears, there is a large amount of marc,[a] and both the seed and marc being insoluble there is a large difference between the total and soluble solids. In the total-solids determinations of the tuna the seeds were not included and the marc is exceedingly small in quantity, as may be seen by taking the difference between the total and soluble solids.

The total solids of the juice is calculated from its specific gravity. This determination should be about the same as the soluble solids and total sugars. Where the sugars are more than the soluble solids or the total solids of the juice, there is probably some error in soluble solids determination. The per cent of total solids of the juice is quite often higher than the soluble solids, due no doubt to the fact that some pulp was in the juice when its specific gravity was taken.

Almost without exception the fruits from Mexico contain more solids and sugar than those varieties native to the United States.

[a] Material insoluble in water.

Composition of edible portion.

Water-soluble proteids (N×4.25).	Acids expressed as H_2SO_4.	Polarizations.		Temperature.	Sucrose by polarization.	Sucrose by reduction.	Total sugars as dextrose (Allihn).	Total ash.	Ash in soluble solids.	Alkalinity of ash as K_2CO_3.
		Direct.	Invert.							
Per ct.	*Per ct.*			°*C.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
.....	0.850	−1.20	−1.70	30	0.38	0.00	3.87	.....	.....	.....
0.284	0.470	−0.10	−2.00	28	1.46	0.93	9.03	.....	0.50	0.400
.....	0.950	+1.00	−1.20	30	1.65	1.97	5.98	.....	.....	.....
0.220	0.220	−1.00	−1.00	28	0.00	0.13	7.51	0.69	0.59	0.538
.....	0.320	.....	.....	.....	.....	0.88	3.94	.....	.....	.....
.....	1.580	±0.00	±0.00	30	0.00	2.60	3.35	.....	.....	.....
0.252	0.742	−0.27	−1.18	29	0.70	1.09	5.61	0.69	0.55	0.469
0.163	0.570	+0.80	+0.80	30	0.00	0.00	4.18	0.81	0.58	.....
0.260	0.070	+3.70	+3.70	30	0.00	0.00	9.44	0.74	0.63	.....
0.193	0.060	+0.30	+0.30	29	0.00	0.00	8.87	0.42	0.89	0.090
0.223	0.047	+2.30	+1.80	29	0.38	0.00	7.82	.....	0.98	0.083
.....	0.137	.....	.....	.....	.....	.....	8.36	.....	.....	.....
0.226	0.099	.....	.....	.....	.....	0.56	9.49	.....	1.20	0.236
.....	.....	.....	.....	.....	.....	.....	8.22	.....	.....	.....
0.167	0.156	.....	.....	.....	.....	0.77	8.66	.....	0.18	.....
0.221	0.322	.....	.....	.....	.....	0.00	4.76	.....	0.90	0.408
0.107	0.690	.....	.....	.....	0.40	0.66	7.11	.....	0.71	0.620
0.100	0.316	.....	.....	.....	0.50	1.19	7.37	.....	0.78	0.440
0.184	0.247	+1.78	+1.65	29.5	0.21	0.13	7.66	0.66	0.76	0.313

of fruit.
whole fruit in potato shredder.

TABLE IV.—*Composition of tunas when peel and seed are rejected.*

Collector's number.	Date of analysis.	Locality.	Scientific name.	Common name.	Number per pound.	Average weight.	Peeling (epidermis).	Seed.	Refuse.	Edible portion.	Composition of edible portion.																
											Total solids.	Soluble solids.	Specific gravity of juice.	Total solids in juice.	Total proteids.	Albuminoids (N×6.25).	Amids (N×4.25).	Water-soluble proteids (N×4.25).	Acids expressed as H_2SO_4.	Polarizations.		Temperature.	Sucrose by polarization.	Sucrose by reduction.	Total sugars as dextrose (Allihn).	Total ash.	Ash in soluble solids.	Alkalinity of ash as K_2CO_3.
																				Direct.	Invert.							
		AMERICAN VARIETIES.																										
						Grams.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*			°*C.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1	Aug. 10, 1905	Agricultural College, N. Mex.	Opuntia macrocentra[3]	Nopal; prickly pear[5]	15.50	29.28	13.31	8.23	21.54	78.46			1.037	8.92					0.850	−1.20	−1.70	30	0.38	0.00	3.87			
4	Aug. 20, 1906	do	do.[4]	do	31.24	14.50			[6]40.32	59.68	12.08	11.63	1.053	12.60	0.393			0.284	0.470	−0.10	−2.00	28	1.46	0.93	9.03		0.50	0.409
2	Aug. 10, 1905	do	Opuntia engelmanni cycloides.	do	25.00	18.09	17.30	11.23	28.53	71.47			1.047	11.23					0.950	+1.00	−1.20	30	1.65	1.97	5.98			
3	Aug. 20, 1906	do	Opuntia laevis (?)	do	15.36	29.50			[6]21.82	78.18	10.11	9.82	1.049	11.69	0.260			0.220	0.220	−1.00	−1.00	28	0.00	0.13	7.51	0.69	0.59	0.538
1	Aug. 1, 1905	San Antonio, Tex	Opuntia lindheimeri	do	10.40	43.51	9.88	6.48	16.36	83.64			1.032	7.74	0.918				0.320					0.88	3.94			
8022	July 30, 1905	El Paso, Tex	Opuntia phaeacantha	do	23.60	19.16	12.06	15.84	27.90	72.10			1.046	11.00					1.580	±0.00	±0.00	30	0.00	2.60	3.35			
		Average			20.18	25.67	13.14	10.45	26.08	74.09	11.10	10.73	1.044	10.53	0.524			0.252	0.742	−0.27	−1.18	29	0.70	1.09	5.61	0.69	0.55	0.469
		MEXICAN VARIETIES.																										
8036	Aug. 6, 1905	San Luis Potosi	Opuntia engelmanni cuija	Tuna cuija	21.52	21.05	11.16	4.22	15.38	84.62	8.45	7.50	1.031	7.51	0.355	0.310	0.045	0.163	0.570	+0.80	+0.80	30	0.00	0.00	4.18	0.81	0.58	
8037	Aug. 7, 1905	do	Opuntia sp	Tuna ranchera	7.90	57.30	11.90	3.02	14.92	85.08	11.72	10.44	1.050	11.92	0.354	0.116	0.238	0.260	0.070	+3.70	+3.70	30	0.00	0.00	9.44	0.74	0.63	
8038	do	do	do	Tuna palmita	13.70	33.10	11.00	5.05	16.05	83.95	12.43	11.15	1.046	11.00	0.843	0.233	0.610	0.193	0.060	+0.30	+0.30	29	0.00	0.00	8.87	0.42	0.89	0.090
8039	do	do	do	Tuna mansa morada	6.80	66.50	17.18	4.65	21.83	78.17	11.62	10.41	1.039	9.38	0.566	0.194	0.372	0.223	0.047	+2.30	+1.80	29	0.38	0.00	7.82		0.98	0.083
8057	Aug. 12, 1905	do	do	Tuna amarilla	4.80	94.00	15.30	5.14	20.44	79.56	11.60		1.045	10.77					0.137						8.36			
8099	Aug. 29, 1905	Aguascalientes	Opuntia streptacantha	Tuna cardona	9.06	50.00	13.24	3.32	16.56	83.44	14.14	13.27	1.046	11.00	0.270	0.104	0.166	0.226	0.099					0.56	9.49		1.20	0.236
[1]8099	do	do	do	do	9.24	49.00	13.24	3.39	16.63	83.37															8.22			
[2]8099	do	do	do	do	9.64	47.00	11.97	2.95	14.92	85.08	12.84	11.51	1.043	10.31	0.351	0.133	0.218	0.167	0.156					0.77	8.66		0.18	
8135	Sept. 15, 1905	do	Opuntia sp	Tuna joconoxtle	11.00	41.17	12.80	4.59	17.39	82.61	7.02	5.34	1.028	6.80	0.382	0.113	0.267	0.221	0.322					0.00	4.76		0.90	0.408
8143	Sept. 20, 1905	Gutierrez	Opuntia leucotricha	Tuna durasnilla blanca	10.60	42.90	2.10	4.90	7.00	93.00	10.28	8.15			0.189	0.108	0.081	0.107	0.690			0.40	0.66	7.11		0.71	0.620
8150	Sept. 22, 1905	Zacatecas	do	Tuna durasnilla colorada	11.10	40.60	13.30	2.96	16.26	83.74	9.30	8.08	1.036	8.68	0.220	0.086	0.118	0.100	0.316			0.50	1.19	7.37		0.78	0.440
		Average			10.49	49.33	12.11	4.02	16.13	83.87	10.87	9.56	1.040	9.71	0.392	0.155	0.235	0.184	0.247	+1.78	+1.65	29.5	0.21	0.13	7.66	0.66	0.76	0.313

[1] Ten days after removing from plant.
[2] Twenty days after removing from plant.
[3] Red juice.
[4] Green juice.
[5] Names of plant; not of fruit.
[6] Obtained by pressing whole fruit in potato shredder.

TABLE V.—*Comparative analyses of different fruits.*[1]

Name of fruit.	Variety.	Weight.	Refuse.	Edible portion.	Composition of edible portion.												
					Total solids.	Soluble solids.	Specific gravity of juice.	Total proteids (N×6.25).	Acids as H_2SO_4.	Polarizations.		Temperature.	Sucrose by polarization.	Sucrose by reduction.	Total sugars, as invert.	Ash.	Alcohol precipitate.
										Direct.	Invert.						
		Grams.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*			°*C.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Pear	Eastern Bartlett	120.00	25.00	75.00	16.97	.....	1.060	0.360	0.146	.....	.....	.....	.....	.....	8.26	0.310	.....
Apricot	.....	62.40	6.00	94.00	14.34	.....	.....	1.250	0.833	.....	.....	.....	.....	.....	11.10	0.508	.....
Blackberry	.....	.....	.....	.....	12.69	7.24	.....	0.919	0.638	− 1.10	−1.00	18	0.16	.....	4.83	.....	0.681
Cherry	.....	.....	5.32	94.68	12.64	10.60	.....	0.650	1.627	+ 0.20	.....	.....	.....	0.00	6.84	0.602	0.668
Banana	Johnson	.....	34.90	65.10	26.13	21.78	.....	1.250	0.333	+11.30	−6.38	27	13.83	11.73	21.71	0.848	.....
Fig	California	.....	.....	.....	20.13	.....	.....	1.344	0.119	.....	.....	.....	.....	.....	15.57	.....	.....
Orange	Florida navel	160.00	26.30	73.70	13.11	.....	.....	0.330	0.686	+ 2.00	−2.50	18	3.33	.....	7.29	0.610	.....
Currant	.....	.....	.....	.....	12.97	6.07	.....	1.369	1.546	− 1.40	.....	.....	.....	0.00	3.44	0.470	0.804
Peach	Elberta	.....	8.07	91.73	15.23	13.28	.....	.....	0.440	+ 7.25	−2.20	27.4	7.39	7.19	9.60	.....	.....
Do	Average of seven varieties	71.66	7.71	92.29	14.45	11.87	.....	0.350	0.560	.....	.....	.....	.....	5.87	7.57	0.520	.....
Apple	Baldwin	180.00	25.00	75.00	13.77	.....	1.075	0.520	0.376	− 2.20	−3.60	18	.....	.....	8.26	0.264	.....
Watermelon	.....	.....	58.00	42.00	7.10	.....	.....	0.300	.....	.....	.....	.....	.....	1.92	4.33	0.370	.....
Tuna	Average of Nos. 8099, 8485, 8142, 8140.	113.00	41.75	58.25	12.96	12.85	1.048	0.413	0.037	+ 1.90	+1.50	26	0.31	0.15	[2] 11.20	.....	0.250
Do	Average of 27 samples	71.17	56.18	42.26	11.74	11.42	1.044	0.377	0.080	+ 1.05	+0.78	27	0.17	0.22	[2] 9.94	0.44	0.242

[1] In compiling this table the analyses were taken from various sources, but they will be found principally in—(a) Buls. 66, 87, and 97, Bureau of Chemistry, U. S. Dept. Agr.; (b) Bul. 28, Office Expt. Stas., U. S. Dept. Agr.; (c) Repts. Cal. Agr. Expt. Sta.; (d) Rept. Mass. Agr. Expt. Sta., 1889. Incomplete analyses of some of the fruits have been in some cases added to from other sources.

[2] These figures were obtained by dividing the dextrose (10.73 and 9.53) by 0.958, the dextrose ratio of invert sugar. See page 31.

PROTEIN.

The proteids are a group of bodies found in greater or less quantity in all foods, but the amount found in any fruit is usually quite small.

Bananas, figs, currants, and apricots have been found to contain over 1 per cent of proteids, but as a rule fruits have less than 0.5 per cent. This is true of the tunas, which average about the same as the pear, the apple, or the peach.

Protein alone can furnish material for building flesh or muscle in the animal body. A man of moderate work will require as much as 1 pound of protein for every 6 pounds of carbohydrates eaten. If the fruit of the prickly pear should have 0.5 per cent of protein and 10 per cent of sugar, and all or equal amounts of both be digested, those Mexicans who make this fruit their exclusive diet would get 20 pounds of carbohydrates for each pound of protein obtained. It is plain to see, therefore, that some other nitrogenous food should be eaten with tunas as with all other fruits to balance the ration.

The proteids are not compounds of definite chemical composition, but they are made up of a group of bodies each differing somewhat from the others in their composition. One element common to all the proteids is nitrogen, but the amount of this element varies in each compound.

The food chemist makes no attempt to separate the various proteids occurring in any food, but he often separates them into two smaller groups of albuminoids and amido bodies, or amids.

ALBUMINOIDS.

The albuminoids are those nitrogenous compounds which more nearly resemble the white of an egg in their composition and function in the animal body. They all contain very close to 16 per cent of nitrogen in the molecule; hence in the method for their estimation in the laboratory the amount present in a food is determined by multiplying the percentage of nitrogen which they contain by the factor 6.25, which has been used in all of the calculations of albuminoids in the tables.

The albuminoids are the most valuable of all the protein compounds because they are the only ones that can serve as building material in the animal body. In an average of all the Mexican samples the percentage of total proteids was 0.377. Of this amount only 0.107 per cent was albuminoids. Thus it may be seen that, roughly, not one-third of the total proteids of the tuna is in the form of albuminoids, which, of course, means that the muscle and flesh forming compounds of this fruit are less than one-third of the total proteids.

AMIDS.

Amids, the other group of compounds into which the chemist divides the total proteids, are a similar group of nitrogenous compounds that are present in plants, especially in their fruits.

They constitute one of the first products formed by the plant in its synthesis of nitrogen with other elements in forming the more complex albuminoids or they are cleavage products in the decomposition of the latter; hence they have fewer atoms in the molecule and a greater proportion of nitrogen. In these calculations it has been assumed that all the amids in the tunas contain 23.53 per cent of nitrogen and the amount present has consequently been calculated by multiplying the percentage of nitrogen which they were found to contain by 4.25.

The amids are not so valuable a food as the albuminoids. They are probably incapable of serving as building material, but may, like the carbohydrates, serve as fuel. They are also thought in some way to protect and prevent the consumption of proteids of the body tissue.

Because of the comparatively large quantity of amids in the total proteids the amount of the latter in the tunas would not be equal in value to the same amount of proteids in meat or many other nitrogenous foods.

In these analyses the water-soluble proteids have been determined, which no doubt include all of the amids and a part of the albuminoids. This determination was made to ascertain the probable available proteids and partly to serve as a check on the total proteids.

ACIDITY.

A study of the tables giving the analyses of the whole fruit as well as the rind and pulp shows the acid to be exceedingly variable in the different varieties of this fruit. In fact, it was found to be variable in different samples of the same variety, depending, no doubt, upon the ripeness of the fruit.

The amount of acid in the rind varies from 0.13 per cent in tuna amarilla (No. 8057) to 0.96 per cent in tuna chaveña (No. 8100). In the pulp of the Mexican samples there was 0.02 per cent in tuna aguamielilla (No. 8119) and 0.32 per cent in tuna durasnilla blanca (No. 8143).

A much greater percentage of acid was found in those samples collected in the United States, with the exception of the tuna tapona, from California, which had only 0.07 per cent. The average acid in the pulp of the samples from San Antonio was 1.2 per cent, while No. 6, from that place, had 2.15 per cent of acid. The ratio of acid to sugar in these six samples was only 1 to 7.5—enough to give the

fruits a decidedly tart taste. While the acid is not too high the sugar is not in sufficient quantity to make the fruits as desirable as the Mexican varieties. One trouble with the Mexican samples seems to be that the ratio between acids and sugars is too great to give them the requisite tartness. For example, the average acids and sugars of these samples show a ratio of 1 to 119, while even such fruits as the banana and fig have a ratio of about 1 to 70 between their acids and sugars, and in some fruits the ratio is as low as 1 to 5 or 6.

It is of interest to note the large amount of acid, 3.48 per cent, in *Opuntia imbricata*, which is the only sample of a Cylindropuntia included in our list. This fruit contains no sugars and is not edible, but was analyzed because of its high acid content. Few, if any, common edible fruits contain so large an amount of acid. The acids in ripe apples rarely exceed 1 per cent; lemons and limes contain only about 5 per cent of citric acid (calculated as sulphuric).

The amount of acid found in the tunas has been expressed in the tables as sulphuric acid (H_2SO_4), because this is the customary manner of expressing such results. This furnishes a ready means of comparing the relative amounts of acid found in different fruits. The acid in several varieties of the tuna has been separated and determined to be malic acid. There were no volatile acids in any of the fresh samples tested.

SUGARS.

Polarizations.—With very few exceptions all fruits and unadulterated fruit products are levorotatory toward polarized light, but an examination of Tables I, II, and IV will reveal the fact that, while some varieties of the tuna were levorotary, most of those examined were dextrorotary both before and after inversion. This unusual phenomenon has caused the writers to devote some little time to a study of the polarizations of the tuna and some of the preserves prepared from them. While in all probability their dextrorotation is due to a large excess of dextrose over levulose, it is impossible to say definitely that such is the case; in fact, the writers can not say definitely whether the dextrorotation is due to dextrose or to some other sugar or substance. "Miel" and "melcocha," two products from the tuna that are prepared by evaporating the juice to the consistency of honey, have small white wart-like crystals somewhat larger than a pin head scattered throughout the mass. These crystals are not so soluble as the rest of the material, and a 50 per cent solution of alcohol dissolves almost everything else, leaving them in a fairly pure condition. When these crystals are separated they are decidedly dextrorotary, exhibit the phenomenon of birotation, give the cobaltous nitrate test, and have other properties in common with dextrose; but a careful separation and study of the

different sugars of the fruit have not been completed. It is impossible to say just what they are or in what proportion they are to be found in the fruits, but the writers have made double polarizations for each sample and from these data calculated the sucrose by Clerget's formula as well as by reduction.

The probabilities are that the sucrose obtained by polarization, which is as a rule more than that obtained by copper reduction, is too high, the apparently large amount of sucrose having doubtless resulted from the birotary action of the fruits in the reading before inversion, which property was destroyed in boiling for inversion.

For a long time the writers were not aware that the fruits contained sugars that were birotary, and this no doubt explains why considerable trouble was experienced in getting uniform results from the same samples, and even sometimes from the same solutions. For this reason the writers are not sure of the accuracy of many of the polarizations reported in this bulletin. It is clearly shown, however, that most of the fruits and their products are slightly dextrorotary. The sucrose and total reducing sugars have both been carefully determined in each sample by copper reduction, and it is believed that these results are fairly accurate.

The difficulties resulting from birotation in the polarizations of the fruits and products may be seen in the results here given of two samples of miel and one of melcocha. These were all read from a one-fourth normal solution which had been treated with lead acetate and alum cream in the usual manner.

Time of experiments.	Miel No. 1.	Miel No. 2.	Melcocha.
Polarization immediately after solution.....	+5.6	+3.9	+3.6
Polarization six or more hours after solution.....	+3.1	+1.8	+2.5

For normal solutions multiply the above figures by 4.

Each of these solutions was read from time to time and its dextrorotation was found to decrease slowly until it reached the last figures given in the table in about six hours, after which it underwent no further change.

By referring to Table I it will be seen that the rind was dextrorotary before inversion in every sample, and after inversion in all but No. 8143 (durasnilla blanca). Another interesting fact concerning the sugars of the rinds of the fruit is that, while they had less reducing sugars, they were often more dextrorotary than the pulp of the same fruit, but there was a greater change in the readings before and after inversion and consequently more sucrose in the rind, for the Mexican varieties at least. The average percentage of sucrose in the pulp of these was 0.17, while for the rind the average

was 0.59. Of all the fruits analyzed that were grown in the United States there was an average of 0.70 per cent of sucrose, while in the Mexican samples there was an average of only 0.21 per cent.

In the analysis of a fruit product it is now customary for the food chemist to report these samples which are dextrorotary as adulterated with glucose. If the tuna or its sugars should ever be added to the products from other fruits sufficiently to cause them to be dextrorotary, it would be necessary to make further tests for glucose adulteration. Since in some localities an enormous yield of the fruits can be produced to the acre on land not well suited to other crops and in a country where labor is cheap, their production for the adulteration of other fruit products is at least an economic possibility.

The large amount of coloring matter, salts of organic acids, mucilage, etc., often makes it very difficult to get a clear solution for reading in the polariscope. The products from the fruits and a few of the fruits themselves had to be treated with both lead acetate and alum cream and at times filtered through animal charcoal when very highly colored.

An attempt was made to remove the coloring matter with sodium hydrosulphite ($Na_2H_2S_2O_5$), but by the use of the reagent alone the writers found that they could not clarify sufficiently. If, however, about one-fourth gram of it was added to a part of the filtrate from the lead acetate and sodium sulphate, it was possible to effectually complete the decoloration. The sodium hydrosulphite reduced the polarizations, however, more than animal charcoal, especially if the solution was allowed to stand a while before reading. This seemed to indicate that the large quantity of sulphur dioxid liberated had some action on the sugars. One sample of miel, after standing until it had lost its property of birotation, polarized at +3.1, but after treating with hydrosulphite and standing for three hours more its polarization was only +2.3.

SUGARS BY REDUCTION.

Under total sugars by reduction in the tables of analyses all the sugars present in the fruits are reported as dextrose. As stated elsewhere, this was done because it was believed that nearly all of the sugar in most of the fruits occurs in this form, rather than as levulose or any other reducing sugar. Sucrose was not often found present, and the probabilities are that often when traces of it are reported it was in fruits that were not thoroughly ripe.

It is customary to report the total sugars in fruits as invert sugar regardless of the kind of sugars present, and in Table V, which is a compilation of the analyses of several fruits from a number of sources,

the total sugars are all reported as invert; but as the copper reducing power is about the same for invert sugar, dextrose, and levulose, the percentages would not differ materially when reported in any of these forms. For further discussion of this point see methods of analysis, page 31.

The percentage of sugar varied a great deal for the different varieties, and, as was to be expected, it varied at times for the same variety, depending, no doubt, upon the season and degree of ripeness.

As previously stated, the only Cylindropuntia analyzed had no sugar; it is doubtful whether the fruits of any of this group contain any appreciable quantity, since none are edible.

The samples from San Antonio, Tex., contained less sugar than those from any other locality; No. 6 had no sugar; No. 3 had only 0.85 per cent. The sample with the largest amount of sugar is No. 8485 (tuna amarilla). This fruit had 11.70 per cent. The sample of this same variety collected in 1905 had 11.07 per cent.

The Mexican samples averaged 9.53 per cent of sugar. The San Antonio samples averaged 2.94 per cent, but No. 2, the highest in sugar from the latter place, had 7.18 per cent. For the six American varieties in which the whole fruit was analyzed the percentage of sugars was 5.61; this it will be seen is more than the average sugar in the pulp of the San Antonio samples, but there are included some that should really be classed with the Mexican samples, since they are cultivated forms of Mexican origin much superior to any received from San Antonio. The average in all of the whole fruits of Mexican samples was 7.66 per cent.

While there was some sugar in the rind of all the samples analyzed, only those that seemed of some probable value were examined. The rind of tuna cardona, No. 8099, and tuna durasnilla (blanca and colorada, Nos. 8143 and 8150) contained more sugars than did the rinds of any of the other varieties.

The products of this fruit which were analyzed contained from 51.06 per cent of sugar in the tunas pasadas to 64.16 per cent in one sample of melcocha.

ALCOHOL PRECIPITATE.

Alcohol precipitate is a term applied to a group of bodies that are precipitated upon the addition of 95 per cent alcohol to the juices of the fruits. Plant mucilage, pectin bodies, and salts of organic acids are among these bodies.

Pectin is that substance which causes the juice to jell when evaporated to the proper consistency, and the object in making these determinations was to estimate if possible the relative quantity of this material present.

The alcohol precipitation in the tuna pulp is considerably less than is obtained from other fruits that are commonly used in the preparation of jellies; the average amount found in all the pulps was 0.29 per cent, while 0.67 per cent is found in the cherry, which perhaps contains about an average quantity for fruits of this character.

The alcohol precipitate of the rind is three or four times that of the pulp. In one sample there was 2.33 per cent, while for all the rinds examined the average alcohol precipitate was 1.29 per cent.

Since the rind contains more alcohol precipitate than an average fruit, one might be led to believe that its juice could be made to jell very readily, but such is not the case. The writers have been unable to make jelly from either the pulp or rind of any of the varieties tested.

A further study of the alcohol precipitate will show that evidently only a very small amount of it, if any, is in the form of pectin. No doubt quite a little of this precipitate is plant mucilage; especially is this true of the rind, which is morphologically the modified stem, and this portion of the plant contains so much mucilage that its juice is very slimy. Yoshimura[a] found this mucilage to be composed principally of galactan. E. F. Ladd[b] states that the mucilage is due to pectosic products, but if such is the case it seems that cooking should cause fruits containing it to jell.

ASH IN ALCOHOL PRECIPITATE.

The amount of ash in the alcohol precipitate has been determined by the writers in the pulp of eight samples and in the rind of three, and the results follow:

Sample No.	Percentage of ash.	
	Rind.	Pulp.
4 (San Antonio)		27.92
8099	40.20	25.10
8135	29.15	26.04
8134		29.16
8136		17.24
8141		24.00
8142		20.34
8146		26.92
8150	51.25	
Average	40.20	24.59

Thus it may be seen that about 40 per cent of the alcohol precipitate from the juice of the rind, and about one-fourth of that from the pulp, is ash.

The amount and character of this precipitate show that something else is precipitated in abundance by the alcohol, together with the

[a] Yoshimura, K. Note on the Chemical Composition of Some Mucilages. Bul., College of Agriculture, Tokyo, Japan, vol. 2, No. 4, pp. 207, 208.

[b] N. Y. Agr. Exp. Sta., Sixth Ann. Rept.

mucilage and pectin bodies, if there be any at all of the latter. Neither of these bodies (pectin and mucilage) would contain so much ash; besides, the precipitate formed would be flocculent in character, whereas in the precipitate from both the rind and pulp there was a decided turbidity, which would indicate the precipitation of salts of organic acids, with possibly some dextrose.

The ashes from the alcohol precipitate are the basic constituents of organic salts of calcium, magnesium, and potassium, and the large amount of these ashes shows that the precipitate is largely composed of organic salts.

STARCH.

The iodine test on the ripe fruits failed to reveal the presence of starch in any of them.

ASH.

The examination of the ash of the cactus fruit has consisted principally in a determination of the amount in the soluble solids. Since nearly all the solids are soluble, the soluble ash is almost equivalent to the total ash. This is seen in the few analyses of total ash recorded in the tables. The average soluble ash in the pulp is 0.29 per cent, which is about the same amount found in apples, pears, or watermelons, and less than is found in the citrus fruits.

As with other plants, the seed of this fruit is quite low in ash, it being in No. 8022, for example, only 0.28 per cent of the whole fruit, which is about the same as is found in the fresh pulp.

The amount of ash in the different parts of the fruit in Nos. 8037 and 8038 is tabulated below:

Part of fruit.	Per cent of ash in sample—	
	No. 8037.	No. 8038.
Rind	1.06	1.40
Whole fruit (pulp and rind)	.74	.42
Pulp and seed	.21	.31

It will be seen that the ash in the pulp and seed taken together is about the same as the average of the pulp alone of all the fruits—0.29 per cent.

The character of the ash is decidedly alkaline. Doctor Bigelow [a] has found this to be true with the ash of fruits generally. The alkalinity of the ash of the pulp calculated to potassium carbonate amounts to 55 per cent of the total ash. The alkalinity of the ash of the rind calculated in a similar manner amounts to 41.18 per cent, while for the whole fruit 48 per cent of the ash is potassium carbonate.

[a] U. S. Dept. Agr., Bureau of Chemistry, Bul. 66.

Very little can be said in regard to the plant food removed from the soil by the tunas until the yield per acre can be determined. The amount of total ash removed by the fruits is very small compared to the amount removed by the stems, which in one instance amounted to 33 per cent of the dried plant.[a] Most of this ash was found to be composed of lime and potash salts, which are in abundance in most semiarid soils, and if so large an amount of these salts is necessary for securing the best results with this plant it will probably never suffer for the lack of them in the Southwest.

It will be interesting to determine whether specimens of this plant that have grown for years in Florida and other parts of the world where there is not such an abundance of soluble salts in the soil continue to have their high ash content. Such is not the case with many other plants, and it is doubted whether the cacti grown in regions of abundance of rainfall will be found to contain so much ash.

The ash is also characterized by a very low content of phosphoric acid. An analysis of the ash from 28 samples of cactus averaged only 1.39 per cent of PO_4, while other plants seldom have less than 4 per cent.

THE SPECIES AND VARIETIES OF TUNAS STUDIED.

TUNA AMARILLA (YELLOW TUNA).

(*Nos. 8057 and 8485.*)

A tall open-branching species 10 to 15 feet high, with a black scaly trunk 8 to 12 inches in diameter; joints narrowly oval, about 7 to 8 by 15 inches, but, of course, variable, bright light green; spicules yellow, not prominent on joints; spines numerous, white, turning to a chalky, mottled, dirty gray, flattened triangular and a little twisted, about 1 inch long, 3 to 15 in number; flower orange, with considerable red in outer segments, giving it a red appearance when closed, style and filaments containing a tinge of red and stigma light green; fruit large, oval to obovate, $2\frac{1}{2}$ by $3\frac{1}{2}$ inches, usually somewhat rough, tuberculate, with greenish rind, becoming reddish yellow on complete maturity, and yellow pulp; formidably protected by large bunches of yellow spicules one-eighth inch long.

Tuna amarilla (*Opuntia* sp.) is a cultivated fruit highly prized by the Mexican people. In addition to the above description, it may be stated that very often the fruit presents a tinge of deep dull red before being cut open, but usually yellow predominates and is decidedly apparent when the fruit is opened. The red coloration is due to streaks of red which run through the rind coincident with the vascular bundles.

Among all the samples of tunas included in our list there is none

[a] See Bulletin No. 60 of the Agricultural Experiment Station of New Mexico.

superior in size and flavor to this one. Of the earlier samples, $4\frac{4}{5}$ would weigh 1 pound, but of the last it required only $2\frac{3}{4}$ to weigh a pound. No. 8485, being the larger of the two samples, had, as was to be expected, less waste material than No. 8057, the smaller one. Especially was this the case when the rind was included in the refuse. There seems to be little or no difference between the two samples other than in size; and a comparison of the analysis of the edible portion of the two will show them to be very similar in composition, although No. 8485 was considerably more mature than No. 8057. The large amount of total solids, soluble solids, and total sugar, together with the high specific gravity of the juice, indicates that this fruit has no superior among the samples included in this study so far as its chemical composition goes. There are few of our highly prized American fruits that will make a better showing in this respect, as may be seen from Table II.

Both samples were found to contain over 11 per cent of total sugars calculated to dextrose. The results showed the presence of very little, if any, sucrose. This was one of the few species that were levorotary after inversion. In fact, the 1906 sample was levorotary to the same degree both before and after inversion.

The rind of this variety is not palatable in the fresh state, and its analysis given in Table I shows that it contains comparatively little sugars (4.09 per cent). Its total solids is high. The refuse material is not so very large compared with that of some of the other varieties, even when the rind is rejected. A comparison of the whole fruit (rind plus pulp) is given in Table III. Since the rind has less nutrients than the pulp, the whole fruit will, of course, have less than the pulp alone.

While the rind of this variety is not eaten fresh, it is one of the varieties used in the preparation of tunas pasadas (dry tunas), which are always dried with the rind left on and subsequently eaten in this form. For this reason separate analyses have been made of the rind and pulp. While the fresh rind has only 4 per cent of sugar, this is greatly increased in the dried rind on account of the large amount of water lost in drying, and the tunas pasadas make a very suitable product for use in cooking in a manner somewhat similar to our dried fruits. A large part of the sugar from the pulp collects on the surface of the rind when dried, and this no doubt helps to make it palatable. The fruits of this variety when dried have over 50 per cent of sugar in the whole fruits.

No. 8057 was collected at San Luis Potosi, Mexico, August 12, 1905.

No. 8485 was collected at Aguascalientes, Mexico, September 10, 1906.

TUNA NARANJADA (ORANGE).

(*No. 8142.*)

The tuna naranjada (*Opuntia* sp.) and the tuna amarilla are really very closely related, but the differences, although slight from a taxonomic point of view, are very constant. The plants, so far as the writers can see, are very much alike in every way, the main difference occurring in the color of the fruit, the pulp of this one being, as the Mexican name indicates, orange instead of yellow. The fruit in both the amarilla and the naranjada is very likely to have its pyriform character accentuated, when the lower portion is flabby and does not contain pulp. Very often this basal portion has a tendency to simulate some of the characters of the joint. Externally this variety is darker colored than the amarilla. Associated with the difference in color of the fruit is often to be found a similar difference in color of other parts of the plant. While size, shape, and color of joints are the same in the two forms, the spicules are somewhat darker in the naranjada, and the same holds true of the flowers.

The fruit is of very fine flavor, somewhat above the average in size, and has a thin rind. The rind is only about one-eighth to three-sixteenths inch thick and constitutes only 32.43 per cent of the fruit. This is one of the fruits in which it was found difficult to separate the seed completely from its pulp by our method of forcing the fruit through muslin, and as a result the total solids are somewhat higher and the percentage of seed a trifle lower than is shown by the analysis. This fruit contains less seed than the majority of the other species. In a number of these undeveloped fruits sterile seeds occur, which suggests a possible gradual disappearance of the seeds through cultivation and selection.

There is 62.57 per cent of edible portion in this fruit, which is more than was found in any of the other tunas analyzed. While, for reasons previously stated, the solids reported in the tables may be slightly low, tuna cardona and tuna amarilla are the only fruits analyzed that had more solids. The cardona had 13.7 per cent of solids, the amarilla 13.56 per cent, and the naranjada 12.92 per cent. The polarization readings on the fruit were +2.1 both before and after inversion, and the total reducing sugars were 9.12 per cent.

Collected at Zacatecas, Mexico, September 20, 1905.

TUNA CAMUESA (PIPPIN, APPLE).

(*No. 8140.*)

A tall open-branching plant 8 to 12 or 15 feet high, with a black, bare, scaly trunk 8 to 12 inches in diameter; joints obovate to ovate, very large, in proportion of 8 by 14 inches in last year's growth, bright dark green, areoles obovate for the most part; spicules yellow and commonly formidable even on the joints; spines usually infrequent

and often absent entirely, but sometimes 1 to 3 in number, never very prominent, white, with translucent, bone-like tips; fruit large, obovate, often $2\frac{3}{4}$ by $3\frac{1}{2}$ inches, dull red, with comparatively thin rind, which is greenish red or streaked and mottled; pulp red and easily separable from the seed.

The tuna camuesa, *Opuntia larreyi* Weber(?),[a] is one of the finest of the cultivated Mexican varieties and belongs in the *Opuntia ficus-indica* group. When the rind is removed, leaving the pulp intact, the latter has a distinct orange cast. When broken open, it is mottled yellow and red, but becomes deeper red with full maturity. It is one of the most palatable of these fruits and has comparatively few seeds, which, of course, is a decided advantage. Oftentimes one-half or two-thirds of the seeds will be found aborted. This has been found to be the case in specimens collected at Los Campos, Aguascalientes, San Luis Potosi, and Zacatecas.

The fruits averaged 163.84 grams each and were the largest of all the samples except those of tapona from Riverside, Cal., which weighed 210.6 grams, and the 1906 sample of amarilla, which weighed 164 grams, or practically the same as the weight of this fruit. These have much fewer seeds than any of the other fruits and a comparatively thin rind, which with the seeds makes a total waste of 43.94 per cent. There is 11.9 per cent of total solids in the edible pulp, nearly all of which is soluble. Acid is present in very small amount, 0.031 per cent. The juice is levorotary to the same degree both before and after inversion, indicating an excess of levulose and no sucrose. The total sugars as dextrose amount to 11.05 per cent.

Collected at Zacatecas, Mexico, September 19, 1905.

TUNA MANSA MORADA (MULBERRY COLORED).

(*No. 8039.*)

A large open-branching tree with huge joints, in age often 11 by 19 inches, and this year's growth 10 by 14 inches, obovate, bright dark green; spicules brown, but not prominent upon the joints; spines white, flattened, turning to a mottled, dirty gray, slightly twisted, with opalescent points, one-fourth to three-fourths inch long, 2 to 3 in number, but increasing to 12 or more at times upon old trunks; erect, spreading, with 1 or 2 lower ones recurved; fruit oblong-obovate, usually slightly tuberculate, with circular areoles one-eighth inch or less in diameter, bearing formidable brown glochids one-eighth inch long, dull red exteriorly; rind reddish yellow, turning to completely red at maturity; pulp blood-red, slightly mottled until dead ripe and clinging tightly to the seed, from which it is difficult to separate it.

The tuna mansa morada (*Opuntia* sp.) is one of the popular tunas of Mexico and one which has not been met with in the open country. For some reason it is not extensively grown, there being only a few plants in scattered orchards. It is finely flavored and of good size.

This sample was analyzed August 14, 1905, seven days after its collection. It was in good condition. The average weight of the

[a] Contrib. U. S. Nat. Herb., 3: 423, 1906.

fruit was 66.5 grams, which is somewhat below the average weight of the Mexican varieties but much heavier than those of the United States. It was one of the first analyzed after this work was undertaken. At that time the significance of the method of preparing the fresh fruit to be eaten was not fully appreciated. For this reason in this sample, as well as in Nos. 8037 and 8038, only the pulp, with that portion of the rind which would naturally remain after peeling the fruits as one would an apple, was analyzed. Nearly all of the best varieties discussed in this bulletin have had the pulp analyzed separately, and it is unfortunate that this fruit was not treated in a similar manner. However, it may be seen from an examination of the composition of the whole fruit, with epidermis and seed rejected, that it compares favorably with the best of those varieties that are reported in a similar manner in Table IV.

Since, as a rule, the pulp alone contains a greater percentage of nutrients than the whole fruit, it is likely that the pulp of this sample would have been about equal in value to that of the tuna cardona. The waste in this sample amounts to 21.83 per cent. If all the rind had been rejected, the waste would have been 46.75 per cent, about the same as in cardona. The total solids amount to 11.62 per cent, all but 1.22 per cent of which are soluble in water. The total solids of the juice calculated from its specific gravity amount to 9.38 per cent. The acidity of the juice is only 0.047 per cent, or less than the average of the pulp alone of all the fruits, which is 0.08 per cent. The average acidity for the whole fruits of all the Mexican varieties is 0.247 per cent. The sugars by reduction are somewhat less than one would expect from the soluble solids and high specific gravity. It is likely that the results for sugar, 7.82 per cent, are slightly low, although they would naturally be somewhat low because of the presence of the rind.

By peeling a quantity of these fruits and exposing them to the sun until air dry, the total dry matter was found to be 17.43 per cent. If the 4.65 per cent of seed be taken from this, there is 12.78 per cent of edible dry matter left, which, considering the small amount of water left in the air-dry sample, checks with the total solids (11.62 per cent) fairly well.

Collected at San Luis Potosi, Mexico, August 7, 1905, the sample consisting of 19 fruits from 4 plants.

TUNA TECA, TUNA BLANCA TECA, TUNA MEXICANA, TUNA AMERICANA.

(*No. 8050.*)

The tuna teca variety (*Opuntia* sp.) is known in the vicinity of San Luis Potosi by all of the appellations mentioned above, and it may be the same as forms which are discussed subsequently under other

names. The distinguishing characteristic of the fruit is that it is greenish white when mature. On the whole, it resembles very much the "mission pear" of the southwestern United States. It is very variable in spine characters, but this particular specimen had spines 2 to 5 in number on last year's joints, but increasing very much with age. The spicules are light reddish brown, seldom prominent upon the joints. The fruit is ovate-obovate, about $1\frac{3}{4}$ to $2\frac{1}{4}$ inches, yellowish green throughout; or, possibly, greenish white would apply better to the pulp. The seeds are apparently few and cling closely to the pulp.

This is a highly prized variety with fine flavor, good appearance, good size, and reasonably thin rind. It is one of the varieties that one will always find upon the market places in season.

An examination of the table will show the similarity in composition between this and the following numbers. In size No. 8050 is about a mean of that of the other two samples (Nos. 8146 and 8547). The waste amounts to 48.1 per cent, which is about the same as that of the other two. They are all characterized by high total and soluble solids but a slightly low sugar content. The total solids for the three amount to about 11 per cent, and the sugar from 8 to 9 per cent. It is easy to tell by tasting them that they are not as sweet as tuna amarilla, for example, but they have a very excellent flavor, which with their large size and thin rind makes them desirable fruits.

Collected at San Luis Potosi, Mexico, August 9, 1905.

TUNA BLANCA (WHITE).

(Nos. 8146 and 8547.)

The tuna blanca (*Opuntia* sp.) may be the same as No. 8050. The people of Zacatecas do not know the name tuna teca at all. This particular specimen is spiny like our "mission pear," but some plants are to be found which are almost destitute of spines or spicules; however, this character is not constant at all, even in the same plant. This tuna sells on the markets of Zacatecas for about the same price as camuesa; indeed, all of the large cultivated forms sell for about the same amount of money.

Both of these samples have been referred to in the discussion of tuna teca (No. 8050), which they very much resemble in both appearance and composition. This is one of the large cultivated fruits and has a good percentage of edible pulp, the seeds of which are often undeveloped and not so abundant as they are in many varieties. No. 8146 weighed 76.3 grams and No. 8547 weighed 123.75 grams. The total solids in the first amounted to 10.81 per cent and in the second to 12.35 per cent. Both fruits were slightly dextrorotary and con-

tained a fraction of 1 per cent of sucrose. There were 8.29 per cent of total sugars in the first and 8.99 per cent in the last sample.

No. 8146 was collected at Zacatecas, Mexico, September 21, 1905.

No. 8547 was collected at Zacatecas, Mexico, September 19, 1906.

TUNA RANCHERA (RANCH).

(*No. 8037.*)

A tall, open-branching tree 8 to 10 or 12 feet high, with black scaly trunk 8 inches, or often a foot, in diameter; joints ovate obovate, with often a tendency to be pointed at both ends, although the prevailing form is obovate, in proportion of 9 by 15 inches, which is a common size, rather light green; spicules yellow, infrequent upon the joints; spines short, one-half to five-eighths inch long, erect, spreading, 2 to 3 or 4 on young joints, but increasing to 10 on 3-year old ones, at this age turning to a dirty gray and apparently dropping off, divergent or a few recurved upon the edges of the joints; fruit large, $1\frac{3}{4}$ by $2\frac{1}{2}$ inches, oval to obovate, with large circular areoles $\frac{1}{3}$ inches in diameter, bearing yellow, formidable spicules and hair-like fugacious spines, very dull, deep red, with some green exteriorly even when mature; rind greenish or mottled yellow and red; pulp, when rind is removed, presenting light orange yellow appearance, but mottled when cut open, the red color being situated mainly around the seed.

The tuna ranchera (*Opuntia* sp.) is a valuable cultivated variety which has a wide range in spine characters, some forms being nearly spineless. The fruit compares favorably in flavor with the other large mansa forms, such as amarilla, but the tunas are somewhat smaller. Although described as mottled, there is usually not enough coloring matter in either pulp or rind for slices of them to stain paper when they are laid upon it. The species should be classed with *Opuntia ficus-indica.*

Tuna ranchera is one of the few good fruits of which, unfortunately, we have no separate analysis of the pulp, both this and the rind having been included in one sample. The analysis given in Table IV will show this to be one of the best fruits so far as total solids and sugar content are concerned. It is about the same size (57.3 grams) as the cardona, and the composition of the edible portion when rind is included is also about equal to that of this fruit when it is prepared and analyzed in a similar manner. It was more dextrorotary than any sample included in our list, being +3.7 both before and after inversion. There was only 0.07 per cent of acid in this sample, which is quite low for any of the tunas where the rind is included with the pulp. A determination of the ash content of the different parts of the fruit shows 1.06 per cent of ash in the rind, 0.21 per cent in the pulp, and 0.74 per cent in the whole fruit.

The fact that there was 85.08 per cent of edible portion simply shows that the fruit was peeled by removing only a very small part of the rind.

Collected at San Luis Potosi, Mexico, August 7, 1905.

TUNA TAPONA[a] (CORK OR PLUG[b]).

(*No. 8065a.*)

When well developed, the tuna tapona (*Opuntia robusta* Wendl.; Cat. Herrenh., 1835) is one of the most attractive of the native Mexican tunas. It is almost globular, more or less tuberculate, and blood red when ripe. It thrives nicely at Riverside, Cal. Like many other species, the pulp becomes edible while the rind, which is red when mature, is still perfectly green. In the early part of the season the fruit upon the market is, therefore, largely green, while later it is blood red. Maturing as it does very early, a great deal of the fruit is destroyed by birds, which eat it as soon as the pulp begins to turn red.

Although large and attractive in appearance, this is not considered a very good species of tuna, mainly on account of the deleterious effects which the Mexicans believe it exerts on digestion. It is said that it has a tendency to produce constipation and that death sometimes results from its use. However, it is extensively eaten.

Collected at Ypina, Mexico, August 18, 1905.

(*No. 8065b.*)

Specimens No. 8065b (*Opuntia robusta* Wendl. (?)) and No. 8065a are closely related, but there are constant differences which prevent our placing them together. No. 8065b is a larger plant throughout, and this is the main difference, although there are other minor points of distinction which when once seen are easily recognized. This one has joints which are larger, more nearly circular, and not so thick and plump as the common tapona of the San Luis Potosi region. The fruits in this variety are also larger, but otherwise the same, and the same distinctions are true regarding the flowers. Both forms grow fairly well at Riverside, Cal., but the writers have never seen this variety growing native like the other. There are nearly spineless forms of both varieties.

Because of its very large size and the fact that it was one of the very few fruits grown in the United States which were analyzed that appeared to be of much value, it is to be regretted that a more complete analysis of it was not made. A complete analysis of No. 8065a was made, however, and probably the greatest difference between these two samples is in size. The waste is less in this one. The solids, determined from the specific gravity of the juice, are just about the same, but there is a great difference in the acidity. No. 8065a contained 0.21 per cent of acid, while this one had only 0.07 per cent.

[a] For description of the plant, see Bulletin 60 of the Agricultural Experiment Station of New Mexico, 1896, p. 69.

[b] Referring to its action on the bowels.

This is doubtless accounted for, in part at least, by the fact that the California sample was more mature.

These fruits are the largest analyzed, being three times the size of those of the tuna tapona from the State of San Luis Potosi, Mexico.

Forwarded from the A. S. White Park, Riverside, Cal., in August, 1905.

TUNA CARDONA.

(*Nos. 8051 and 8099.*)

The tuna cardona (*Opuntia streptacantha* Lem.[a]) (see Pl. I) is without doubt the most highly prized of all the Mexican tunas. It is smaller than the cultivated varieties, but is very palatable, and the Mexicans say it may be eaten in quantity without any deleterious effects. The whole fruit is purplish red throughout, with a pulp of much deeper color than the remainder, and the epidermis showing considerable scaly wax covering when fully ripe. In shape it is oval to subglobose, about $1\frac{1}{2}$ to $1\frac{7}{8}$ inches in longest diameter. The fruit resembles very closely the tuna cochinera and the tuna artona. It is rather doubtful whether it is specifically distinct from the latter, but it is certainly distinct from the former.

Many of the cultivated species produce larger tunas and ones which are just as palatable, if not more so; but the cardona has several advantages over the others. It is abundant, cheap, a native species, very palatable, and with no deleterious qualities such as the tapona and some of the others are said to possess. Frequently it is planted, but not usually, in protected orchards, for it is sufficiently spiny to need no protection. Cuttings are commonly planted in the open country, in order to extend the native thickets. It is especially abundant upon the markets of San Luis Potosi, Aguascalientes, and Zacatecas, where one may often find piles containing 30 to 40 bushels brought in from the surrounding hills and deserts.

In view of the fact that this is the most abundant, widely distributed, and most universally used of all the Mexican species considerable time has been devoted to a study of the composition of both the pulp and rind, and an analysis of both of these parts will be found in Tables I and II, respectively, while in Table IV an analysis of the fruit without the seed and epidermis is also given. In order to determine the effect of storage on the composition, analyses of samples at three different periods of storage have also been made, both in 1905 and 1906. The first analysis given in the table is that of the fresh fruit immediately after its receipt in the laboratory; the second that of fruit selected from the same lot as the first after

[a] Cact. Gen. et Sp. Nov., 62, 1839. See Bulletin 60 of the Agricultural Experiment Station of New Mexico, 1906, p. 65.

standing ten days, while the third is the analysis of fruits that had been stored, as packed for shipment, for twenty days.

The tuna cardona is at least equal in nutritive value to any of the tunas, although considerably below the average in size and not quite as highly flavored as the amarilla, the naranjada, or the camuesa.

Sample No. 8051 was smaller and had more rind and seed than the other two samples. It had only 34.8 per cent of edible pulp, 11.47 per cent of solids, and 9.76 per cent of sugar as dextrose, this being less than was found in the other samples, doubtless due to the fact that eighteen days elapsed between the collecting of this and the second sample, thus giving the latter time to more fully mature.

No. 8099 was, as stated above, analyzed at three different periods for both the years 1905 and 1906, and the results are reported under Nos. 8099, 8099a, and 8099b in Table II. The rind was also analyzed and the results reported in Table I. No marked difference in the composition of the pulp or rind of the fruit when stored was noticed beyond what might be expected in different fruits of the same variety. One very noticeable change on standing, however, was the loss in weight of the rind and a corresponding decrease in the weight of the pulp. For the purpose of showing these changes the weights and percentages of the fruit and its rind and pulp for the different periods of storage during the seasons of 1905 and 1906 are given in Table VI.

TABLE VI.—*Effect of storage on weight and relative amounts of rind and pulp of the tuna cardona.*

Condition of fruit.	Weight in grams.		Rind.		Pulp.	
	1905.	1906.	1905.	1906.	1905.	1906.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Fresh	50	60.5	42.66	48.92	54.02	47.69
Stored for ten days	49	53.15	51.53	50.0	45.08	46.75
Stored for twenty days	47	.....	61.70	.....	35.35	.....

The figures here given would seem to indicate that the water in the fruit passes from the pulp into the rind, but if such is the case this movement takes place without any material change in the composition of either pulp or rind that could be detected in the analysis.

The amount of acid in this fruit was unusually low both in the pulp and the rind. In the pulp of all the samples it averaged 0.05 per cent, and in the rind 0.21 per cent, which is less than half of the average for all the other Mexican samples.

The juice of every sample of No. 8099 tested was dextrorotary before and after inversion. Sometimes both polariscope and reduction methods showed a very small amount of sucrose in the pulp, and still more in the rind, which at times seemed to have as much as 1.5 per cent. The rind of none of the fruits contained as much total

sugar as did this one, 7.2 per cent, which is almost as much sugar as the pulp of average temperate-zone fruits. The total sugars as dextrose were determined in seven different samples of cardona, and the average for these determinations was 10.22 per cent.

No. 8051 was collected at Alonzo, Mexico, August 11, 1905.

No. 8099 was collected at Aguascalientes, Mexico, August 29, 1905.

No. 8436 was collected at Aguascalientes, Mexico, September 4, 1906.

TUNA PALAMITA.

(*No. 8038.*)

A tall, open-branching cultivated pear 10 or 12 feet high with a black scaly trunk 6 to 10 inches in diameter; joints obovate, in proportion of 6½ by 12 inches, which is a common size, slightly bluish green, becoming cracked and scaly with age; areoles obovate, about one-sixteenth by one-eighth inch, but increasing slightly with age; wool tawny; spicules light brown; spines flattened, triangular, twisted, some recurved, others erect divergent, one-half to 1 inch long, white with opalescent darker points, 2 to 4 in number, but increasing to 6 or 7 at age of 3 years, and increasing slightly even beyond this, but becoming abraded from old trunks; fruit about 1½ by 2¼ inches, ovate obovate, mottled, and dull red when fully matured, rind finally turning to a streaked brownish red and pulp mottled.

The tuna palamita (*Opuntia* sp.) is formidably protected with light-brown spicules one-sixteenth inch or more long from circular areoles about one-half inch apart. It is well flavored, but not promising, on account of the many spicules. The writers have never seen this species except in cultivation. The fruit is sweet and palatable, and were it not for its small size (33.1 grams) and large number of spicules it would be very desirable. No separate analysis was made of the pulp, unfortunately; but judging from the analysis of the whole fruit there are few tunas whose edible portion shows a superior composition. There is 12.43 per cent of total solids in the whole fruit and 8.87 per cent of sugar.

Collected at San Luis Potosi, Mexico, August 7, 1905.

TUNA AGUA-MIELILLA (HONEY WATER).

(*No. 8119.*)

A tall, open-branching native tree 12 to 25 feet high with a bare scaly black trunk 10 to 14 inches in diameter; joints ovate obovate, about 8 by 12 inches, which is a common size, deep dark green, soon turning to a gray black; spicules reddish brown, but never prominent upon the joints; spines white, becoming mottled, flattened, twisted, erect, divergent, 4 to 6, with lower and usually two laterals recurved; flowers (only two or three seen) deep orange, with red in midribs of outer segments, always causing them to look red when closed; style bright red, filaments lighter red, stigma yellow with streaks of red through outside of the 6 or 8 divisions; fruit small, subglobose to obovate, about 1½ inches in longest diameter, deep dark red with darker pulp, which is easily separable from seed, formidably protected with small circular areoles containing bunches of reddish brown glochids surrounded by the blackened ends of the wool.

As the popular name suggests, the agua-mielilla (*Opuntia* sp.) (Pl. IV, fig. 2) is a very sweet and palatable tuna, but it is too small to compare favorably with the cultivated forms and the better wild species, such as the cardona. These fruits averaged 30.84 grams in weight, which is less than half the average size of the Mexican species. Another serious objection is the large percentage of refuse in rejecting the thick rind, which amounts to 57.72 per cent. The solids and soluble solids (10.98 and 10.78 per cent, respectively) are high. The acid (0.024 per cent) is less than was found in any of the fruits. The percentage of proteids (0.89 per cent) is not high for fruits generally, but is more than was found in the other samples of prickly pears.

The total sugars amount to 8.84 per cent. No sucrose was found by reduction methods and only a very small trace by polarization, the readings being to the right before and after inversion. Because of the large quantity of rind an analysis was made to determine the nutritive value of this portion. The results are recorded in the table of analyses of the rinds (Table I), and from these it may be seen to have 7.27 per cent of solids in the juice, of which only 2.76 per cent is sugar.

Collected at Dublan, Mexico, September 12, 1905.

TUNA LEONERA.

(*No. 8102.*)

A tall, very open-branching tree 15 feet high, largely used for hedges and line plantings. Joints deep dark green, about the same color as the cardona, obovate, about 5 to 7 inches by 8 to 12 inches; spicules reddish brown, not formidable upon the joints, really seldom visible except in the spineless areoles at the base; spines 4 to 7 on last year's joints, but increasing very much on old wood, white, turning to a mottled condition and finally to dirty black, flattened, twisted, 1 to 2 inches or more long, and erect, with upper shorter, spreading, and lower usually recurved; flowers (only two seen) orange with greenish filaments, reddish style, and light green stigma; fruit almost globular, deep dull red, with pulp darker and rind of medium thickness, formidably protected with reddish brown spicules from small circular areoles about one-fourth inch apart; seed easily separable from pulp.

The tuna leonera (*Opuntia* sp.) is small, but has a very good flavor, and is consequently well thought of in parts of Mexico. It is eaten fresh and also employed in the manufacture of miel, melcocha, and queso, for which it is said to be admirably adapted. The composition of the edible portion, as seen from the analysis in Table II, shows it to be one of the three best fruits, but, as with agua-mielilla, its small size and thick rind prevent it from being classed as high as it would otherwise be. The fruits weighed only 30 grams, and 68.66 per cent of this was rind, which, with the 3.33 per cent of seed, left only 28.01 per cent of edible pulp. The solids of the edible portion

amounted to 13.21 per cent, 10.78 per cent being sugar. By reduction none of this was found to be sucrose, and polarization only showed 0.38 per cent. Both polarizations were to the right.

Collected at Encarnacion, Mexico, September 1, 1905.

TUNA PACHONA.

(*Nos. 8141 and 8546.*)

A tall, rather compactly branched tree 10 to 15 feet high, with a black, scaly trunk 6 to 10 inches in diameter; joints ovate-obovate, about 7 by 13 inches, deep dark green, with waxy white covering often prominent, resembling the cardona in color very much, but on the whole a little lighter; areoles 1 to 1¼ inches apart, ovate to circular; spicules bright reddish-brown, but often yellowish at their bases, not often formidable on joints except at the bases of the younger ones; spines white, flattened or triangular, with translucent, bone-like tips, usually slightly twisted, somewhat but never tightly recurved, 2 to 5 in number; flowers not seen; fruit red, becoming decidedly purplish when fully matured, formidably protected with large bunches of reddish brown glochids from large circular areoles.

The tuna pachona (*Opuntia* sp.) is a bright, clear red fruit, which becomes deep red to purple when completely ripe. It is one of the most attractive of the leonero–opalilla–agua-mielillo group, and is largely used in the manufacture of queso and other pulp products. It sells on the day of collection upon the markets of Zacatecas at the rate of seven or eight for a cent, while amarillas, camuesas, etc., are selling at the rate of two for a cent.

The tuna pachona closely resembles the tuna cardona in composition. The average weight of the individual fruits of the cardona variety collected in 1905 was 49 grams, while the pachonas for the same year averaged 48.2 grams. The two resemble each other also in having a "mealy" juice—that is, when the juice is expressed there is a considerable amount of very finely divided solids in suspension.

The pachona sample collected in 1906 (No. 8546) was about the same in size as the one collected in 1905, and the amount of seed and rind, as well as the composition of the pulp, was about the same in both. The total solids amounted to about 12 per cent, and a calculation of the solids in the juices of the two from their specific gravity shows this to be not far from 12 per cent for both samples, while the reducing sugar amounted to about 9 per cent.

Strange to say, No. 8141 was dextrorotary to a fraction of a degree both before and after inversion and No. 8546 was slightly levorotary in both cases. The latter was more fully matured than the former.

No. 8141 was collected at Zacatecas, Mexico, September 19, 1905.

No. 8546 was collected at Zacatecas, Mexico, September 19, 1906.

TUNA CHAVEÑA.[a]

(Nos. 8100 and 8136.)

When fully ripened the tuna chaveña (*Opuntia* sp.) does not differ very much in outward appearance from the tuna cardona. It is, however, slightly longer and lighter in color, especially during the ripening period. It differs also in being protected by yellow instead of reddish brown spicules and in maturing about six weeks or two months later. The chaveña and its closely allied varieties are among the latest to mature in the autumn. With it its two varieties are almost always associated. The tuna caidilla differs from it in having rather smaller joints and in the one important characteristic of dropping its fruit as soon as mature. The Spanish name "caidilla" is probably derived from "caier," to fall. The fruit is said to remain in good condition upon the ground for a month or six weeks. The other variety is the tuna cascarona, differing also from the chaveña in having somewhat larger and more uniformly circular joints and possibly slightly larger tunas. These three forms are very closely related and would scarcely be considered distinct species by the most critical taxonomist, but they are quite well recognized by the Mexicans, who will pick them out, especially during the fruiting season, with considerable certainty. As previously stated, the tuna chaveña, together with its varieties, matures late in the season, and its fruits are best adapted for winter use. In the vicinity of Aguascalientes large quantities of these are stored and placed upon the market continuously through April. They are packed, as stated elsewhere in this bulletin, in well-aerated situations in alternate layers with straw or hay. Specimens which were examined as late as the middle of April were in a good state of preservation.

Although somewhat underripe, No. 8100 had evidently attained its full growth and sugar content. The tunas averaged 11.23 grams heavier than the fruits of No. 8136, which were gathered in the same locality two weeks later. This variety is about an average size, but it is characterized by a very large amount of rind in proportion to pulp. The percentage of seed is somewhat less than was found in some of the other varieties, but the proportion of rind is very large, and is not edible. When this was rejected the total refuse was about 75 per cent. Because of the large amount of waste, the rind of No. 8100 was analyzed and found to contain 4.97 per cent of sugar. The acids were rather high in the rind (0.96 per cent), which was probably due to the fruit not being thoroughly ripe. Both samples were somewhat similar in composition. The percentage of solids, sugars, and proteids of No. 8136 was somewhat greater than was found in the greener sample, by far the greatest difference being in the pro-

[a] See Bulletin 60 of the Agricultural Experiment Station of New Mexico, 1906, p. 73.

teids. The polarizations were to the right in both samples both before and after inversion. No sucrose was found by reduction in either, but the polarizations seem to show 0.24 per cent in No. 8136. This is about an average of the Mexican fruits so far as sugar and proteids are concerned. The test with iodin failed to show any starch in No. 8100.

Neither sample changed its color when evaporated to dryness on the water bath as do many of these fruits.

No. 8100 was collected at Aguascalientes, Mexico, August 29, 1905. This specimen was obtained from the very earliest tunas to mature and was really considerably underripe. The natives had not yet begun to use these fruits.

No. 8136 was collected at Aguascalientes, Mexico, September 15, 1905. This specimen was none too ripe, although the ripest fruits obtainable were selected for the analysis. The natives were just beginning to eat them at the time this sample was collected.

TUNA DURASNILLA BLANCA (WHITE PEACH).[a]

(*Nos. 8143 and 8545.*)

The tuna durasnilla blanca (*Opuntia leucotricha* DC.)[b] is a light yellow fruit when mature and reaches a size of $1\frac{7}{8}$ by $2\frac{1}{4}$ inches, but is usually smaller than this. It is one of the very few aromatic tunas of Mexico, although Mr. Francis Eschauzier states that this is a common characteristic of the tunas which have become naturalized in southern Spain. Differing from many species, the rind of this fruit assumes more of the consistency and flavor of the pulp when mature and is consequently eaten, the practice usually being to cut off the peel rather roughly, leaving about one-half of it attached to the pulp when the operation is completed. In this way about one-half of the peel is consumed with the pulp. To many foreign tastes this is a pleasant fruit on account of its slight pungency, the other species being often complained of as insipid. This, however, is no more true of the tunas than of many other subtropical fruits. See the discussion under No. 8150.

No. 8143 was collected at Gutierrez, Mexico, September 20, 1905.

No. 8545 was collected at Zacatecas, Mexico, September 19, 1906.

TUNA DURASNILLA COLORADA (RED PEACH).

(*No. 8150.*)

The writers are unable to discover any constant difference, except that of color, between No. 8150 (*Opuntia leucotricha* DC.)[c] and No.

[a] See Bulletin 60 of the Agricultural Experiment Station of New Mexico, 1896, p. 75.

[b] Rev. de la Fam. de Cact., 119, 1829.

[c] Rev. de la Fam. de Cact., 119, 1829. See Bulletin 60 of the Agricultural Experiment Station of New Mexico, 1896, pl. 4.

8143. Both forms are aromatic and both are eaten with a portion of the peel attached to the pulp. Both have formidable spicules and hair-like fugacious spines of the same color. The rind and epidermis are most highly colored in this variety. The pulp becomes red very tardily, and then it is only mottled, the red being confined to that part of the pulp adjacent to the seed.

This fruit resembles No. 8143 as much in its chemical composition as in its botanical and physical characteristics, and for this reason the samples are discussed together. Since both rind and pulp of these two fruits are usually eaten, a complete analysis has been made in both fruits of each of these portions separately, as well as of the whole fruit (minus seed and peel), and the analyses as given in Tables I, II, and IV will show a remarkable similarity in the composition of the different parts of both. The average weight of each sample was 42.9 grams for No. 8143 and 40.6 grams for No. 8150, both being considerably below the average weight and size of the largest tunas.

Like the tuna chaveña (Nos. 8136 and 8100), these fruits have a very thick rind (about three-eighths of an inch), but inasmuch as it is palatable this can not be offered as much of an objection to them; yet while the rind of both fruits is superior to the rind of other fruits examined, with the exception of the tuna cardona (No. 8099), it is not equal in value to the pulp either in composition or flavor, and the same fruit with a thinner rind would, of course, be preferred. As mentioned before, it is doubtless the presence of a large amount of plant mucilage and salts of organic acids that renders the rinds unpalatable, and in No. 8150 these were found to be present in less than one-half of the quantity usually found in this portion of the fruit, as shown by the amount of alcohol precipitate (see Table I). The amount of ash was also considerably less in both samples than is usually found in the rind. About the only marked difference in the two fruits is in the amount of acid, there being more than twice as much acid in the white variety (No. 8143) as was found in the red sample (No. 8150).

While as before stated these fruits are quite similar in composition, there was found somewhat more pulp in the durasnilla blanca than in the durasnilla colorada, but the total and soluble solids, the proteids, specific gravity, and sugars are practically the same in both. As in the rind, the acid in the pulp of the former is more than twice that in the other. Both of these fruits are smaller and contain less sugar and other nutrients than some of the other samples, but the palatability of their rinds makes them desirable fruits.

Collected near Zacatecas, Mexico, September 22, 1905.

TUNA VINATERA.

(*No. 8134.*)

A tall, open-branching plant, often 12 to 15 feet high, with a gray scaly trunk 8 to 12 inches in diameter; joints prominently pubescent, tuberculate, narrowly obovate, 3 to 4 inches by 10 to 14 inches in last year's growth, light yellowish green; spicules lemon yellow, very formidable near base of joint but not so prominent above, often one-fourth inch long; spines white, erect, spreading, flattened, and twisted, with prominent translucent, bone-like tips, as much as $1\frac{3}{4}$ inches long, 2 to 4 or 5 in number, very formidable and stout, increasing rapidly with age and enlarging the areoles upon the old trunks to often one-half inch in diameter, and containing as high as 30 strong spines; flowers deep orange with red in midribs of outer segments, which are irregularly serrated and often cleft; filaments and style red, with pulp deeper colored than rind and clinging closely to seed, pubescent, tuberculate, deeply pitted at top, in this respect much like fruits of some of the species of Nopalea, formidably protected by yellow glochids from triangular areoles three-sixteenths to five-sixteenths inch apart.

Although very pleasantly flavored, the tuna vinatera (*Opuntia* sp.) has many disadvantageous characteristics. The fruit is small, the pulp clings closely to the seed, and the spicules are very numerous. It is quite extensively eaten in the field but seldom found upon the markets and is not very highly prized. It is the smallest of any of the fruits analyzed with the exception of one or two samples of little or no nutritive value. This variety averages only 24 grams per fruit, but the rind is not so thick as in some of the other fruits of good quality, like the leonera and the agua-mielilla. The edible pulp constituted 50.17 per cent of the fruit, and this had 12.14 per cent of solids, nearly all soluble, 10.22 per cent being sugar. No sucrose was found by reduction, and only a trace by polarization, the polarization being +2.3 before and +2.1 after inversion.

Collected at Aguascalientes, Mexico, September 16, 1905.

TUNA JOCONOXTLE.

(*No. 8135.*)

A medium-sized, rather compactly branched native plant 6 to 10 feet high, with a gray scaly trunk 6 to 8 inches in diameter; joints large, obovate, in proportion of 8 by 11 inches, which is a common size, minutely papillate hairy, soft and silky to the touch, dull green, becoming yellow and scurfy and finally gray scaly; areoles circular, about 1 inch apart; spicules yellow and rather prominent even on joints; spines white, turning to a dirty gray, flattened, slightly twisted, weak, erect divergent, very unequal in length, longest about 1 inch, the lower often somewhat recurved; flowers yellow; fruit subglobose to slightly obovate, about $1\frac{3}{4}$ inches in diameter, dull red with pulp deep red and rind lighter, papillate hairy, with circular to obovate areoles about one-fourth inch apart.

There are several very distinct varieties which pass under the common name of joconoxtle (pronounced *ho-con-ox-tle*) (*Opuntia* sp.). We are not certain that they all belong even to the same botanical species. The most obvious characteristics are found in fruit colora-

tion, but there are other taxonomic distinctions also. This variety has fruit red or reddish purple throughout. Another variety has green fruit with red pulp; another has fruit green throughout when fully mature. All of the varieties agree, however, in one respect, namely, they are not palatable in the fresh state. They need to be cooked before being eaten.

The rind in this species is comparatively thick and the pulp not palatable. It is therefore not eaten until cooked. Its main value is in the manufacture of preserves, for which there is a large use.

A rather complete analysis has been made of both rind and pulp, and the composition of these parts, as well as that of the whole fruit, is reported in the different tables. The average weight of this variety is 41.17 grams, which is below the average weight of tunas generally. Of this, 68.46 per cent is rind, only 26.95 per cent being pulp free from seed. The tuna joconoxtle contains less nutrients than any of the edible samples received from Mexico, with the possible exception of the tuna cuija.

A comparison of the analysis of the whole fruit of these two samples in Table IV shows the total and soluble solids in the joconoxtle to be 7.02 and 5.34 per cent, respectively, while for the tuna cuija they are 8.45 and 7.50 per cent, respectively. But the cuija has only 4.18 per cent of sugar, while the joconoxtle has 4.76 per cent in the whole fruit. The pulp of the latter has 7.74 per cent of sugar, but there are no data for sugar in the pulp of the former.

These are the only tunas from Mexico with less than 10 per cent of total solids and with so low a percentage of sugar. In this respect they more nearly resemble those forms native to the United States.

Collected at Aguascalientes, Mexico, September 15, 1905.

PRICKLY PEAR, NOPAL.[a]

(Nos. 1 to 6, William Sinclair, collector.)

Very little use is made of the fruit of *Opuntia lindheimeri* Engelm.,[b] and our analyses show that it has comparatively little merit as a food. Occasionally a family is found which makes a sort of preserves of the peeled fruits; others dry them, while still others eat them in the fresh state. Usually the fruit simply drops off of the plants and is eaten by hogs and cattle. There is a strong opinion prevalent among both Americans and Mexicans in portions of southern Texas that the fruit produces injurious effects. However this may be, it is certain that it is very often eaten, although not very palatable, with no injurious consequences.

[a] Names of the plant. These names apply to all species of the flat-jointed Opuntias.

[b] Boston Jour. Nat. Hist., 6: 207, 1850. See Bulletin 60 of the Agricultural Experiment Station of New Mexico, 1906, p. 32, and Bulletin 91 of the Bureau of Animal Industry, U. S. Dept. of Agriculture, pp. 9–11.

Six samples of this species have been analyzed, all collected by Mr. William Sinclair at San Antonio, Tex., as follows:

(1) Collected August 1, 1905. This is the only one of those fruits from San Antonio, Tex., which had the pulp and rind analyzed together as one sample, and for that reason it is not readily comparable with the other five samples in its solids and its sugar content, but it is probably one of the best fruits from that locality.

The tables show about twice as much sugar in sample No. 2, which was collected six or seven weeks later in the season, but the solid matter is about the same for both, and the difference in sugar can be largely accounted for by the fact that the rind is included in sample No. 1.

The tables show a high percentage of edible portion because only the seed and a very thin epidermis are included in the waste. The fruits were crimson in color, averaged 43.5 grams in weight, and were about $1\frac{1}{2}$ by $2\frac{1}{2}$ inches in size. The sample had 3.94 per cent of total reducing sugars and 0.88 per cent of sucrose. The determination of total solids was lost, but the solids in the juice calculated from the specific gravity were 7.74 per cent.

(2) Collected September 19, 1905. This sample of *Opuntia lindheimeri* was collected about seven weeks later than the previous one and was the largest and best sample from San Antonio. The fruits were $1\frac{3}{4}$ to 3 inches in diameter and weighed on an average 71.63 grams. The rind of this sample was very thick (about one-fourth inch in its thinnest part) and was a very deep purple. As in all the samples from Texas, there was a large percentage of waste. There were 7.78 per cent of total solids and 7.18 per cent of total sugars.

(3) Collected November 17, 1906. The individuals in this sample averaged about 1 by $1\frac{1}{2}$ inches in size and weighed 25 grams. Like all the fruits of this species, they were sour and unpleasant to the taste. In some of the fruits the pulp was gray or yellowish green in color. The rind was very thick and constituted 67 per cent of the total. Only the pulp was included in the analysis, and this amounted to 25 per cent of the fruit. It had only 5.68 per cent of solids. Of these solids, 1.18 per cent was acid, 0.48 per cent proteids, and 0.85 per cent total sugars. If this fruit were palatable the small amount of edible portion and the low percentage of solids and sugar would render it of little value.

(4) Collected July 4, 1906. The pulp only was included in the analysis of this sample. It amounted to 33.29 per cent of the whole fruit. There was 7.8 per cent of solids, of which 7.27 per cent was soluble, 5.24 per cent was sugar, and 0.88 per cent was acids calculated to H_2SO_4. It is interesting to note that while this fruit contained only 5.24 per cent of sugar it was the best sample of this

species. It was levorotary before and after inversion, both polarization and reduction showing a fraction of 1 per cent of sucrose.

(5) Collected October 16, 1906. This sample consisted of small somewhat shriveled green fruits, a number of which had begun to decay. They averaged 21 grams in weight. The rind was green to the pulp, but this was of a bright scarlet color.[a] Like the other samples, the proportion of rind and seed was very large, and only 32 per cent was edible. Of this, 7.13 per cent was solids and only 1.41 per cent was sugar. The writers were unable to notice any effect upon polarized light by the juice.

(6) Collected November 6, 1906. These fruits weighed on an average 26.54 grams. The pulp had only 5.33 per cent of solid matter, and this was quite unpalatable, as may readily be understood by referring to its analysis as given in Table II. Of this solid matter, 2.15 per cent was acid, and the fruits contained no sugar whatever.

SAMPLE NO. 2, NEW MEXICO COLLEGE GARDEN.

Both rind and pulp of Sample No. 2 (*Opuntia engelmannii cycloides*[b]) were of a deep red color; they averaged about 1½ by 2 inches in size, weighed 18.1 grams, and had about 200 seeds three-sixteenths inch in diameter.

In the analysis of this sample the rind was included with the pulp. The refuse, consisting of seed and peel, amounted to 28.53 per cent. The solids, calculated from the specific gravity of the juice, constituted 11.23 per cent. Of this, 1 per cent was malic acid, and 6 per cent was reducing sugars. By reduction 1.97 per cent of sucrose was obtained. By polarization it was 1.65 per cent.

In the vicinity of Hillsboro, N. Mex., the fruit of this species is prepared as an attractive palatable sirup. The juice is expressed in a fruit press, and is then boiled to one-fourth its original volume after the addition of one-sixth its weight of cane sugar. Boiling does not destroy the color in the least. The finished product is not only palatable, but is attractive in appearance.

Collected at Agricultural College, N. Mex., August 10, 1905.

TUNA CUIJA.

(*No. 8036.*)

The tuna cuija, pronounced *quee-cha* (*Opuntia engelmannii cuija* G. & H.[c]), is a deep purple fruit which ranges from subglobose to pyriform, about 1¼ by 2¼ inches in size, and is one of the most variable

[a] A common characteristic of late fruit of this species.

[b] Engelmann and Bigelow. Pacif. Ry. Rep., 4:37, pl. 8, fig. 1, 1856. See Bul. 60 of the Agricultural Experiment Station of New Mexico, 1896, p. 40.

[c] N. Mex. Expt. Sta. Bul. 60, pl. 2, 1906. For description, see Bul. 60, Agr. Exp. Sta. of New Mexico, 1906, p. 44, pl. 2.

species. Some forms are worthy of cultivation, being quite palatable and having a good proportion of pulp, while others are not fit to eat. When overripe, the color is very deep, almost black—so much so that the vendors upon the market places where they are sparingly sold often call them "tuna negra." The fruit is quite comparable with that of *Opuntia lindheimeri*. The areoles are very similarly distributed and the spicules somewhat more abundant.

No separate analysis was made of the pulp of this variety, but the analysis of the edible portion of the whole fruit shows this to be of little value compared to most of the other Mexican varieties. It resembles the joconoxtle in its composition, but the fruits are only about one-half as large, the average weight of the cuija being only 21.05 grams. The refuse is reported in Table IV as only 15.38 per cent of the fruits, but this is because the rind was all included in the edible portion, except the thin epidermis. The total solids of the fruits were 8.45 per cent, but only 4.18 per cent was sugar.

Collected at San Luis Potosi, Mexico, August 6, 1905.

SAMPLE NO. 3, NEW MEXICO COLLEGE GARDEN.

The average weight of the fruits of Sample No. 3 (*O. lævis?* Coulter[a]) was 29.5 grams. They are of a dark purple color, and the juice is a brilliant red both for the rind and pulp. The pulp was separated from the rind and seed in a press. The edible portion obtained by this process amounted to 78.18 per cent of the fruit. The total solids were 10.11 per cent and the sugars 7.51 per cent. This was one of the few prickly pear fruits that were levorotary both before and after inversion. By polarization no sucrose was found, and only 0.14 per cent was found by reduction; it contained 0.22 per cent of acid calculated as H_2SO_4.

This is probably the most palatable prickly pear that is at present found growing in New Mexico, and while it is not eaten as a fresh fruit very extensively, it is used considerably by the Mexicans in the preparation of preserves.

Some of the pulp of this fruit was evaporated to about one-eighth of its original volume to a thin paste, without suffering any change in its color. This paste was used for coloring apple jelly and candy, and was found to serve admirably for the former purpose. Because of the danger or prejudice against the use of coal-tar dyes it may have some value commercially as a vegetable coloring matter. Candy colored by means of it lacked the brilliancy of that colored with coal-tar dyes, and it is doubtful whether it could ever be very generally used for this purpose. The paste prepared in this manner

[a] Contrib. U. S. Nat. Herb., 3: 419, 1896. See Bul. 60, Agr. Expt. Sta. of N. Mex., 1906, p. 43.

had 51.6 per cent of sugar, only 0.48 per cent being sucrose. By removing the sugar and insoluble solids from the material the coloring matter could probably have been concentrated to as rich a color as cochineal paste. The coloring matter of this fruit will be more fully investigated during the coming season.

Whether or not the fruits will ever prove of commercial value for the preparation of a coloring matter will, it is believed, depend solely upon the yield to the acre that can be obtained. This can only be determined by experiment.

Collected from the cactus garden of the New Mexico Agricultural College, August 20, 1906.

SAMPLE NO. 8022.

Sample No. 8022 (*Opuntia phaeacantha* Engelm.[a]) is rather small and too acid to be of use as an article of human food. It is pyriform, about 1 by 1½ inches, rather sparingly beset with small areoles having formidable yellow glochids one-eighth inch or less long. It is light reddish purple without and has a rind of the same color, but the pulp, which is quite acid, is greenish yellow and the seeds are comparatively large.

It will be seen that this brief description varies somewhat from that given in Bulletin 60 of the Agricultural Experiment Station of New Mexico. The writers can not tell about the character of fruit of the type of *Opuntia camanchica* for reasons stated in that publication, and the description is not explicit. It may be necessary later to admit under this specific name forms with fruits bearing the following colors:

(1) Reddish purple throughout.

(2) Reddish purple on outside and greenish yellow within.

(3) Reddish purple epidermis and rind and greenish yellow pulp.

The fruit was prepared for analysis by peeling the skin or epidermis with as little waste of the rind as possible, which was analyzed, together with the pulp, freed from seed. There was in this sample 15.84 per cent of seed, this being more than was found in any of the samples analyzed. The peel was only 12.06 per cent, making a total waste of seed and peel of 27.9 per cent.

The total and soluble solids were not determined in this sample, but the solids in the juice calculated from its specific gravity were 11 per cent, and the sugars amounted to only 3.35 per cent, making a purity coefficient of the juice of only 30.5 per cent, while with the juices of the best fruits it was as high as 80 to 90 per cent. This low coefficient in the purity of the juice is found in all the fruits with a

[a] Mem. Am. Acad. (Plant. Fend.), 4:52, 1849. See Bulletin 60 of the Agricultural Experiment Station of New Mexico, 1906, p. 50, for notes on this and *Opuntia camanchica*.

low sugar content when the rind was included with the pulp in the analysis. The other solids doubtless consist of acids, salts of organic acids, and mucilage—1.58 per cent is acid calculated as H_2SO_4.

Reduction methods showed 2.6 per cent of the sugar to be sucrose, but we are inclined to believe that there must be an error in these results, since the juice seemed to have very little, if any, effect on polarized light and no sucrose was found by polarization.

Collected at El Paso, Tex., July 30, 1905.

SAMPLES NOS. 1 AND 4. NEW MEXICO COLLEGE GARDEN.

At the time of collection it was noticed that there were two kinds of mature fruits on the different plants in a plantation of this species (*Opuntia macrocentra*[a]) upon the college campus. They resembled each other in their outward appearance, except that sample No. 1, collected in 1905, was about twice the size of sample No. 4, collected in 1906. The pulp of No. 1 was red, while that of No. 4 was green or yellowish green. The fruits of sample No. 1 averaged 29.28 grams, while those of No. 4 weighed only 14.5 grams each.

Sample No. 1 was prepared for analysis by peeling off the epidermis and forcing the pulp and rind through muslin. The amount of edible portion obtained in this manner amounted to 78.46 per cent. The edible portion in No. 4 was obtained by subjecting the fruits to pressure and weighing the juice thus obtained. In this way only 59.68 per cent was edible. The total solids in No. 1 was not determined, but a calculation from the specific gravity of the juice shows the solids in this sample to be 8.92 per cent. The total solids in No. 4 was 12.08 per cent and the soluble solids 11.63 per cent. Calculated from the specific gravity of the juice the solids present in No. 4 amounted to 12.60 per cent. No. 1 had 0.85 per cent of acid, and No. 4 had 0.47 per cent, or about half the amount found in No. 1.

Both samples were levorotary at both readings and seemed to have some sucrose, the larger quantity being in No. 4.

No. 1 had 3.87 per cent of total sugars as dextrose and No. 4 had 9.03 per cent. The small fruit with the green pulp which was collected in 1906 was a better fruit than the one collected in the previous year, as may be seen from its composition. It has more solids and sugar and less acid. Whether this is due to the season, the fact that it was collected ten days later in the month, the difference in the size of the two samples, or varietal difference, the writers can not say. A difference in the color of the pulp is common in the prickly pears. Similar differences to the one noted here are common in *Opuntia engelmannii, O. lindheimeri, O. phaeacantha*, and many others.

[a] Engelmann, George. Synopsis of the Cactaceæ of the Territory of the United States and Adjacent Regions. Proc. Am. Acad. Arts & Sci., 3:292, 1857.

TUNA JUELL.

(*No. 8035.*)

Tuna juell (*Opuntia imbricata* (Haw.) DC.[a]), pronounced *whay*, is the common cylindropuntia of the highland region of Mexico. The fruit is not eaten by either man or beast, so far as the writers have been able to determine. As the analyses show, it is very high in acid, and because of this and the presence of so much plant mucilage and the absence of sugar it is not at all palatable.

Before the advent of coal-tar dyes this fruit had an important place in the arts. The tunas were gathered, chopped up into small pieces, and boiled, the fiber and seed being filtered out and the extract used to dissolve and set cochineal dye. It is still used in this way to a limited extent. Experiments which the writers have conducted show it to be somewhat efficient for the purpose, especially in the coloring of woolen cloth. Its mordanting property is doubtless due to the large amount of acids and salts of organic acids present.

This is the only analysis of cane cactus (Cylindropuntia) included in this bulletin. The fruit of this group of cacti is not edible, nor was this particular sample. The analysis was made to determine its composition compared to the prickly pears. The fruits averaged 51.66 grams in weight. The percentage of seed was 9.68, which is higher than was found in any of the fruits except *Opuntia phaeacantha* (No. 8022).

The total solids were only 7.57 per cent, 5.54 per cent being soluble in water. The juice contained an unusually large quantity of plant mucilage, which rendered it so slimy that the writers could not determine the specific gravity at all by means of a Westphal balance, and upon attempting this determination with a gravity balance the unavoidable bubbles in the slimy juice caused the specific gravity to be only 0.903, or less than that of water, which is, of course, too low. The proteids present were about an average of what is usually found in the other tunas. The fruit contained 3.48 per cent of acid, which was found to be malic acid. This large percentage suggests a possibility of the use of the plant in the preparation of malic acid. No trace of sugar was found either by reduction or polarimetric methods.

An analysis of the ash of the soluble solids in this fruit is given below. A comparison of its composition with the composition of the ashes of the stems of the cacti as given in Table 2 in Bulletin No. 60 of the Agricultural Experiment Station of New Mexico shows it to be comparatively low in lime and high in alkali salts and sulphates.

[a] Prodromus, 3: 47, 1828; *Cereus imbricatus* Haw., Rev. Pl. Suc., 70, 1821. See Bulletin 60 of the Agricultural Experiment Station of New Mexico, 1906, p. 97, pl. 7, fig. 2.

Composition of the ash in the soluble solids of the tuna juell.

	Per cent.
Silica, iron, and alumina (SiO_2,Fe_2O_3,Al_2O_3)	0.64
Chlorin (Cl)	4.09
Sulphuric acid radicle (SO_4)	5.12
Calcium (Ca)	7.15
Magnesium (Mg)	6.83
Sodium (Na)	Trace.
Potassium (K)	33.81

Collected at San Luis Potosi, Mexico, August 9, 1905.

MEXICAN STRAWBERRY.

(*No. 5, New Mexico College Garden.*)

The Mexican strawberry (*Echinocereus stramineus*[a]) is the only fruit included in this study outside of the genus Opuntia. The genus Echinocereus includes many species with edible fruits. In fact, the fruits of this genus are often preferred to the prickly pears, but their scarcity prevents their extensive use as a food. The fruits in the sample were collected somewhat late in the season and were probably not as good as some that matured earlier. They will not stand storage as well as prickly pears, for they ferment very quickly after being collected. These fruits are of a salmon color, weigh about 18 grams, and average 2 inches long and 1 inch in diameter at the largest part. They are formidably covered with long white spines, but these are completely and easily brushed off when the fruit is ripe. The fruit is covered with a greenish rind, which constitutes 30.38 per cent of the whole, but this represents the total refuse, since the small black seeds, which are almost as small as those of the strawberry, are eaten, and for this reason were included with the edible portion. The edible portion, therefore, amounted to 69.17 per cent, which is more than that of any of the prickly pears with their rinds rejected. The percentage of total solids of the edible portion amounted to 18.14, which is also higher than that of the prickly pear and can be explained, in part at least, by the presence of the seeds. The fruit differs from the prickly pears in containing nearly 3 per cent of sucrose. Its polarization readings were +1.3 before and −2.5 after inversion at 28° C. The total sugars were 9.3 per cent. The unusual amount of sucrose for a cactus fruit made them much sweeter than the prickly pears.

The juice had a very pleasing odor and taste, and if the plants were as abundant as the prickly pear they would be preferable as a food, as they are more palatable and do not, like the tuna, contain so many seeds that can not be masticated or readily removed from the pulp. Neither do they have so much plant mucilage as the tunas.

Collected August 17, 1906, from garden on campus of New Mexico Agricultural College.

[a] Engelmann, George. Synopsis of the Cactaceæ of the Territory of the United States and Adjacent Regions. Proc. Am. Acad. Arts & Sci., 3: 282, 1857; U. S. & Mex. Bound. Sur., 2: 35, 1859.

PLATES.

DESCRIPTION OF PLATES.

PLATE I. *Frontispiece.* Tuna cardona. A native and the most important of the prickly pears of the northern highlands of Mexico. Reduced to one-third natural size.

PLATE II. Harvesting the tuna cardona. Fig. 1. Gathering tunas for immediate consumption. Fig. 2. Peeling tunas for immediate consumption.

PLATE III. Drying tunas (tunas pasadas). Fig. 1. Peeling tunas for drying, Montesa, Mexico. Fig. 2. Drying tunas in the sun, Montesa, Mexico.

PLATE IV. A tuna seeder and several large prickly pears. Fig. 1. A seeder dissected. Fig. 2. Nopal agua-mielillo, Dublan, Mexico.

PLATE V. Prickly pear thickets. Fig. 1. A temporary camp in a pear thicket at harvest time, State of Zacatecas, Mexico. Fig. 2. First crop of tunas the second year from cuttings having two or three joints (nopal manso morado), San Luis Potosi, Mexico, August 20, 1906.

PLATE VI. Seeds of edible tunas. Natural size. Fig. 1. No. 8142, tuna naranjada. Fig. 2. No. 8036, tuna cuija. Fig. 3. No. 8037, tuna ranchera. Fig. 4. No. 8038, tuna palamita. Fig. 5. No. 8039, tuna mansa morada. Fig. 6. No. 8135, tuna joconoxtle. Fig. 7. No. 8134, tuna vinatera. Fig. 8. No. 8136, tuna chaveña. Fig. 9. No. 8141, tuna pachona. Fig. 10. No. 8050, tuna teca, tuna blanca teca. Fig. 11. No. 8051, tuna cardona (*Opuntia streptacantha*). Fig. 12. No. 8150, tuna durasnilla colorada. Fig. 13. No. 8143, tuna durasnilla blanca. Fig. 14. No. 8146, tuna blanca. Fig. 15. Tuna camuesa (*Opuntia larreyi* Web., type from Engelmann herbarium). Fig. 16. No. 8140, tuna camuesa (*Opuntia larreyi(?)*). Fig. 17. No. 8065b, tuna tapona (*Opuntia robusta* Wendl.(?)). Fig. 18. No. 8065a, tuna tapona (*Opuntia robusta* Wendl.).

FIG. 1.—GATHERING TUNAS FOR IMMEDIATE CONSUMPTION.

FIG. 2.—PEELING TUNAS FOR IMMEDIATE CONSUMPTION.

HARVESTING THE TUNA CARDONA.

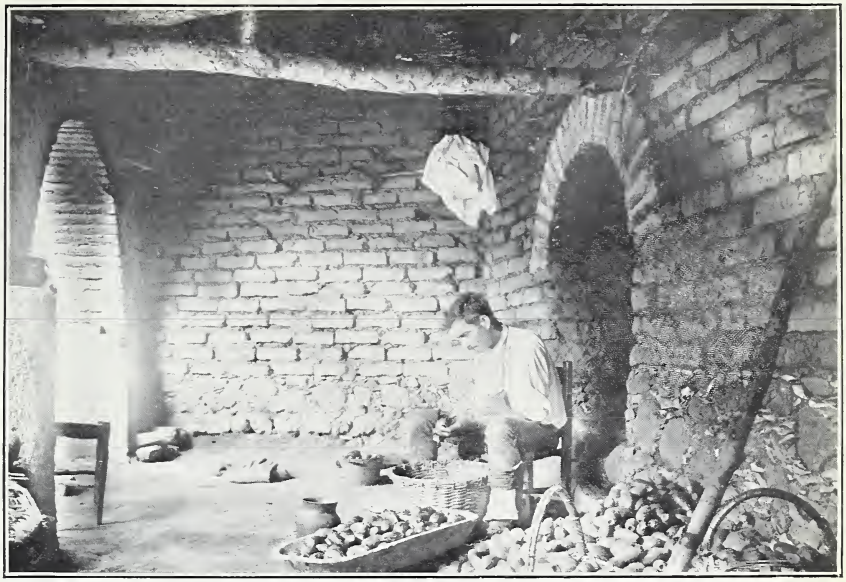


FIG. 1.—PEELING TUNAS FOR DRYING, MONTESA, MEXICO.

FIG. 2.—DRYING TUNAS IN THE SUN, MONTESA, MEXICO.

DRYING TUNAS (TUNAS PASADAS).

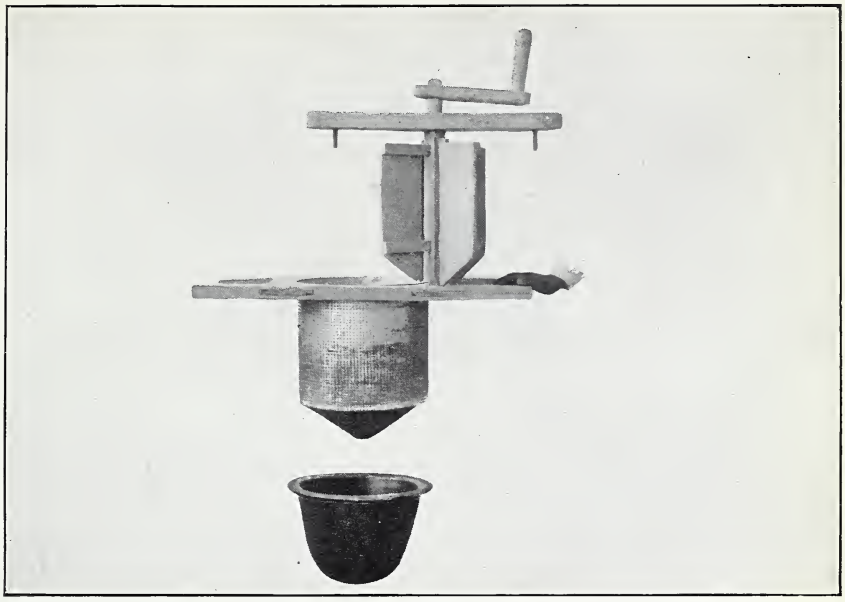


FIG. 1.—A SEEDER DISSECTED.

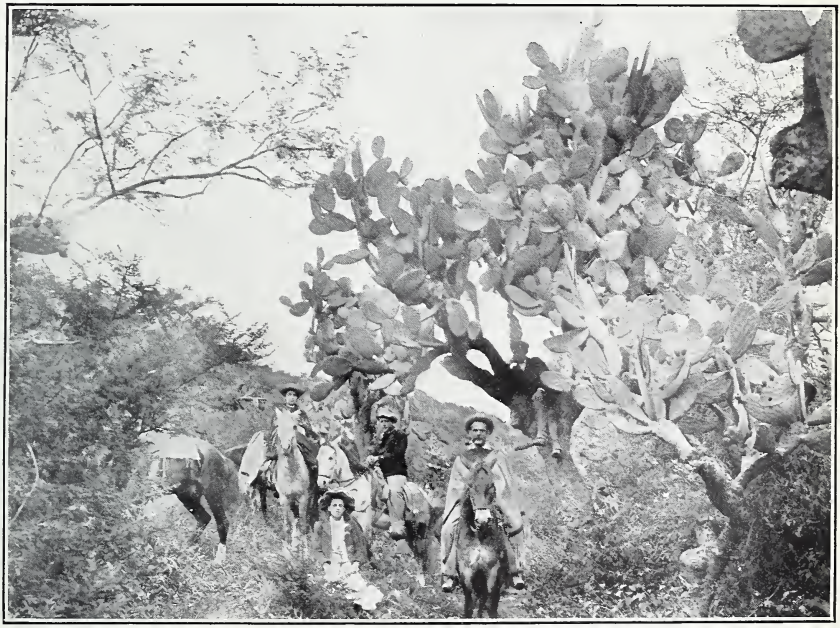


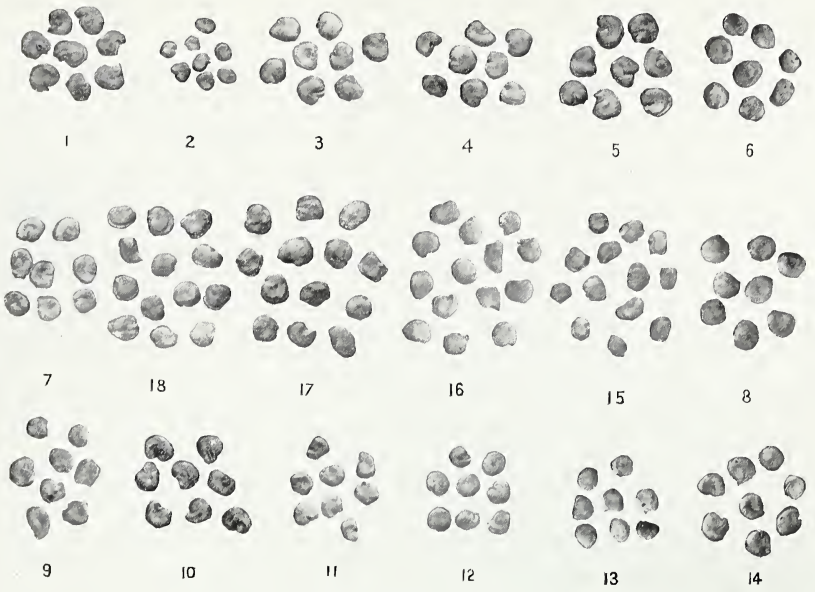
FIG. 2.—NOPAL AGUA-MIELILLO, DUBLAN, MEXICO.

A TUNA SEEDER AND SEVERAL LARGE PRICKLY PEARS.

FIG. 1.—A TEMPORARY CAMP IN A PEAR THICKET AT HARVEST TIME, STATE OF ZACATECAS, MEXICO.

FIG. 2.—FIRST CROP OF TUNAS THE SECOND YEAR FROM CUTTINGS HAVING TWO OR THREE JOINTS (NOPAL MANSO MORADO), SAN LUIS POTOSI, MEXICO, AUGUST 20, 1906.

PRICKLY PEAR THICKETS.



SEEDS OF EDIBLE TUNAS.

(Natural size.)

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